Municipal and County Engineering

DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF ALL PUBLIC WORKS

Vol. LXIX DECEMBER, 1925 No. 6

CONTENTS

"Pay As You Go" Plan of Highway Financing 287
Asphaltic Pavements on Old Macadam or Gravel Bases in Grand Rapids, Mich. 292
The Cost of Inadequate Street Lighting 293
Work of American Construction Council 295
Resolutions of State Highway Officials 297
Data on Mosquito Control Methods 298
Recent Highway Research Developments 303
President of A. A. E. Addresses Frank Letter to Members 305
Economic Aspects of Snow Removal from Highways 306
Heavy Subgrade Soils Not Improved by Adulteration 309
The Improvement of Grade Crossings 310
Efficiency in Concrete Road Construction 311
Controlling the City's Finances 321
Prevention of Deposit in Water Mains 323
Economics of Strengthening and Widening Pavements 325
Special Uses of Asphalt Distributors in Road Maintenance 337
Modern Street Lighting 336
California Motor Revenues Less Than Estimated 339
Surface Treatment of Gravel Roads with Asphaltic Oils 340
Widening and Thickening California State Highways 343
Highway Police and Highway Safety Devices 345
Varying Quantity of Cement in Plain and Reinforced Concrete 349
Court Decision Affecting Chlorination 350

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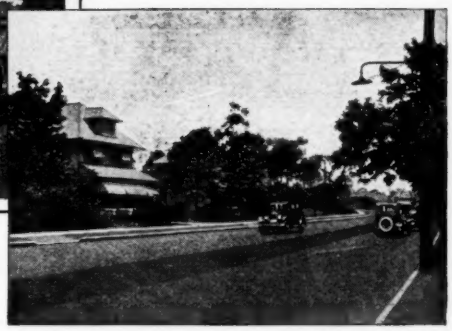
Stephenson Boulevard, New Rochelle, N. Y., July 8, 1924.



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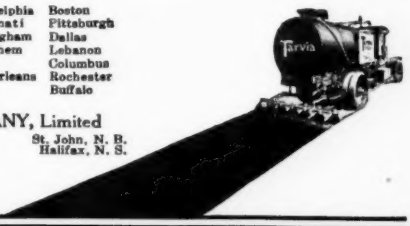

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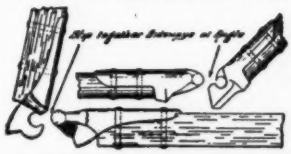

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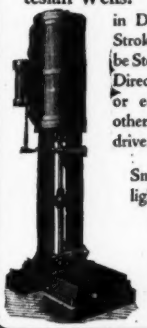

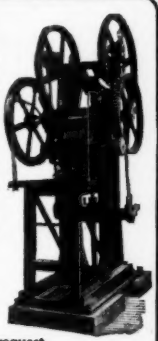

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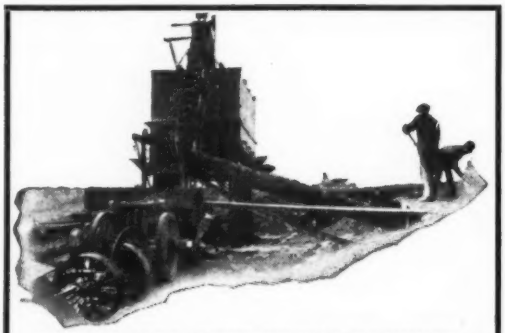

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INDEX TO ADVERTISEMENTS

Alvord, Burdick & Howson, Chicago, Ill..... 12
American Steel & Wire Co., Chicago, Ill..... 14
American Telephone & Telegraph Co., New York, N. Y. .....
American District Steam Co., North Tonawanda, N. Y. .....
Asphalt Association, New York, N. Y.....
Austin Machinery Corporation, Toledo, Ohio
Austin-Western Road Machinery Co., Chicago, Ill. 14

Barrett Co., The, New York, N. Y..... 3
Brossman, Chas., Indianapolis, Ind..... 12
Buffalo-Springfield Roller Co., Springfield, O.
Buyers' Guide 6, 8, 10

Cannelton Sewer Pipe Co., Cannelton, Ind..... 13
Carey Co., The Philip, Cincinnati, Ohio.....
.....Inside Front Cover
Caterpillar Tractor Co., San Leandro, Calif... 16
Chicago Paving Laboratory, Chicago, Ill..... 12
City Wastes Disposal Co., New York, N. Y... 12
Clay Products Association, Chicago, Ill.....
Coldwell-Wilcox Co., Newburg, N. Y..... 7
Cummer & Son, F. D., Cleveland, Ohio..... 13

Dallman Machine & Manufacturing Co., Milwaukee, Wis. .....
Dee Clay Mfg. Co , W. E., Chicago, Ill..... 13
Dee, Wm. E., Chicago, Ill..... 7
De Laval Steam Turbine Co., Trenton, N. J.
Dow & Smith, New York, N. Y..... 12
Druar & Milinowski, St. Paul, Minn..... 12
Du Pont De Nemours & Co., E. I., Wilmington, Del. .....

Engineers and Contractors 12, 13

Flood, Walter H., Chicago, Ill..... 12
Ford Motor Co., Detroit, Mich..... 5

Harris Air Pump Co., Indianapolis, Ind.....
Holophane Glass Co., New York, N. Y.....
Howard, J. W., New York, N. Y..... 12
Hunt, Robt. W. Co., Chicago, Ill..... 12

Jones, Sam L., Cincinnati, Ohio..... 12
Jordan & Steele Mfg. Co., Inc., Charlotte, Mich. .....

Kalamazoo Foundry and Machine Co., Kalamazoo, Mich. 7
Kentucky Rock Asphalt Co., Louisville, Ky...
Keystone Driller Co., Beaver Falls, Pa..... 9
Kirchoffer, W. G., Madison, Wis..... 12
Kissel Motor Car Co., Hartford, Wis.....
Koehring Co., Milwaukee, Wis.....

Littleford Bros., Cincinnati, Ohio.....
Luten, Daniel B., Indianapolis, Ind..... 12

Marion Machine Foundry & Supply Co., Marion, Ind. 9
Murphysboro Paving Brick Co., Murphysboro, Ill. 7

National Paving Brick Mfrs. Ass'n., Cleveland, Ohio .....

Olsen Testing Machine Co., Philadelphia, Pa. 13

Pennsylvania Salt Mfg. Co., Philadelphia, Pa.
Pierce-Arrow Motor Car Co., Buffalo, N. Y....
Pioneer Asphalt Co., Lawrenceville, Ill..... 9
Portland Cement Association, Chicago, Ill...
..... Back Cover
Potter, Alexander, New York, N. Y..... 12

Rosing, Inc., Astrid S., Chicago, Ill..... 12

Smith Co., The T. L., Milwaukee, Wis.....
Standard Oil Co. (Indiana), Chicago, Ill.....
.....Inside Back Cover
Stewart, W. H., St. Louis, Mo..... 7
Strickler, W. W., & Bros., Columbus, Ohio.... 7
Sullivan, Long & Hagerty, Bessemer, Ala..... 13

Texas Co., Asphalt Sales Dept., New York, N. Y. .....
Truscon Steel Co., Youngstown, Ohio.....

United States Cast Iron Pipe & Foundry Co., Burlington, N. J. 9

Van Trump, Isaac, Chicago, Ill..... 13

Warford Corporation, New York, N. Y.....
Warren Brothers Co., Boston, Mass..... 1
Wells, James P., Rochester, N. Y..... 13
Westinghouse Electric & Manufacturing Co., South Bend, Ind.....

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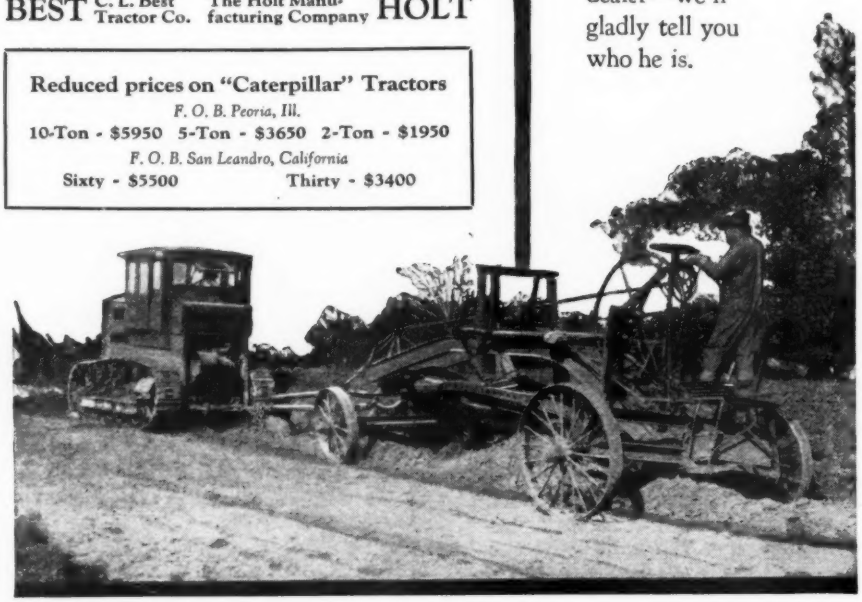

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"PAY AS YOU GO" PLAN OF HIGHWAY FINANCING

By J. T. Donaghey, State Highway Engineer, State Capitol Annex, Madison, Wis.

(Editor's Note: The following address was delivered at the meeting of the American Association of State Highway Officials at Detroit on Nov. 19, 1925.)

The subject assigned me, which is that of highway financing, is one that has been discussed by many men who have made a closer study of the subject and are much better equipped to discuss it than I. However, in most cases the subject has been discussed purely from the angle of providing funds by one of the three following methods: (1) By a direct tax upon general property; (2) Issuing bonds for a term of years, retiring the bonds when due, and paying the interest annually by a direct tax upon general property; and (3) By issuing bonds and retiring the bonds when due and paying the interest annually with revenues from motor vehicles.

Many states or subdivisions thereof have financed highway improvements by some one of the three plans mentioned above, and in but very few instances can opponents of any of the three plans show where the public has not received reasonably full value for the funds expended and highway service to the extent of several times the total cost of the improvements. Even where bonds have been issued for the construction of highways, the same running for a period of 20 years or more, and the surface of the road constructed has become worn to such an extent that a new surface was required before the bonds were retired, it is not proved that the public which must finally provide the funds for retiring the bonds has not received in highway service several times the cost required to meet the bonds and interest. The very fact that the surface has become worn to such an extent that a new surface is required is good evidence that the traffic was extrmely heavy. There is still available the basic portion of the road for future use; that is, the right of way, roadbed and drainage structures.

Many writers contend that general property should pay the cost of right of way, grading and drainage structures, and that a just charge against the motor vehicle would be to provide and maintain the wearing surface. This sounds like a reasonable solution of the problem and would be, could it be carried into effect in all instances.

There is, however, one matter that few have taken into consideration when discussing highway financing, and that is the value of the present highways before improvement. Every American state, or its subdivisions, has a large mileage of public highways. These highways, when originally laid out and opened for travel, were an obligation against the taxable property of the subdivision, and the right of way, grading and drainage structures on this vast mileage that the road builders of today are inheriting was provided by a direct property tax. The taxpayers of the different units of government have from year to year expended large sums for the improvement of the old roads, which are not all a total loss when reconstruction is contemplated. I dare say that the average mile of public highway as we find it in the average unit of government today is worth to us when taken over for improvement not less than $8,000, and this sum must be considered when figuring the fair proportion that general property should pay by a direct tax.

During the past five years public sentiment has gradually drifted toward requiring the motor vehicle to pay a larger share of the cost of improving the highways they use, and to provide a method whereby each motor vehicle owner pays in proportion to the amount of service he receives as nearly as can be estimated. This sentiment has resulted in practically every state in the Union adopting a gasoline tax, in most cases to supplement a former license fee. There is but little sentiment against a play of this kind in those states that have adopted it, providing the motor vehicle revenues have been honestly and conscientiously expended upon the highways in which the motor vehicles owners are interested. In fact, the general feeling of motor vehicle owners is that they would rather pay a much higher amount annually than they are now paying in order to get adequate highway service as soon as reasonably possible.

Any plan that provides for using the entire motor vehicle revenues of a state for the construction of a limited primary highway system is not economically sound and will not result in general satisfaction to the motor vehicle owners of the state for any great length of time.

In the average agricultural state, fifty per cent of the motor vehicles are owned

in the agricultural communities. Those owners are entitled to and must receive recognition when plannig the expenditure of the annual fees they pay for the privilege of operating their motor vehicles.

I propose to discuss the "Pay As You Go Plan" of Highway Financing by suggesting an adjustment in motor vehicle revenues to an annual amount sufficient to provide the necessary funds to construct an adequate system of Primary and Secondary highways as fast as it is practicable to construct the same, and to maintain both the primary and secondary systems before they are finally improved as well as after, thus giving the motor vehicle owners the best possible highway service from the very beginning.

It is not a waste of motor vehicle revenues to expend the same for the improvement of earth roads by supplying a light gravel surface prior to their final improvement. Neither is it a waste of funds to maintain both the earth and gravel surfaces in an adequate manner at all times.

In discussing this subject, we will consider an average Mid-Western agricultural state. This average state has 80,000 miles of public highways. We will assume that seven per cent of this mileage, or 5,600 miles, constitutes an adequate primary highway system and will eventually require a high type surfacing, and that ten per cent of the total, or 8,000 miles, constitutes an adequate secondary system, which should eventually be surfaced with gravel or some other light type of surfacing that will keep traffic out of the mud. In other words, seventeen per cent of the total highway mileage of this average state should eventually be improved with some kind of all weather surface to properly serve traffic.

This average state has a population of 2,600,000; a true valuation of $5,000,000,000; and a motor vehicle registration of 600,000. We find these three important factors go hand in hand, and there is very little variation in the proportion of each in the several Mid-Western agricultural states. There is, of course, a considerable variation in the industrial states of the East and the undeveloped states of the West. Assuming that these three factors do go hand in hand in the average agricultural state, it matters but little in the long run whether highway improvement is financed by direct taxation or by a tax upon the motor vehicles, as practically every family in such states now owns one or more motor vehicles. The pricipal provisions of a highway law should be to compel each user of the highway to pay according to the services he receives.

To own and operate 600,000 motor vehicles in this average state will require the stupendous sum of $273,000,000 annually. This is an average of $455 per motor vehicle. Included in this cost is interest on the investment, depreciation, insurance, housing, plus the general upkeep and operating cost of the vehicle, which is conservatively estimated as follows:

600,000 motor vehicles at an average cost of $750 represents a total investment of $450,000,000.

When you have applied the above estimates to your own car, you will agree that the figures used are thoroughly conservative. Each motor vehicle in this average state is now paying in license fees and gas tax $21.00 annually, which is but 4.4% of the total annual cost of owning and operating such motor vehicles.

It is generally conceded that it costs two cents per mile more to operate a car on an average earth surface than on a concrete or other high type surface

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and one cent per mile more on an average gravel surface than on concrete or other high type surfaces. Assuming that these figures are correct and that the average car travels 5,000 miles per year, the difference in the cost of operating a motor vehicle per mile per year on a concrete surface as compared with an earth surface is $100; the difference between a concrete surface and a gravel surface is $50; and the difference between a gravel surfac and an earth surface is $50 per year. These figures, which I am sure are conservative, prove conclusively that the motor vehicle owner can well afford to pay much more annually towards highway improvement providing the funds are expended on the highways he uses and by so doing will have a net saving annually on the cost of operating his motor vehicle.

No plan of highway financing, where the motor vehicle owner pays the bill, is complete or fair unless it includes the construction and maintenance of roads other than a primary system.

In order to determine the roads which the motor vehicle owners use in Wisconsin, the highway department conducted a very interesting traffic survey during the summer of 1923 in several separate units of government, nine of which were agricultural townships located in different sections of the state. A representative of the Commission called upon every farmer living in each of the nine townships and got the following information from them personally:

1. How many miles of annual highway travel, both auto and team.
2. Miles traveled on primary or state trunk highways.
3. Miles traveled on secondary highways, in Wisconsin called County Trunk Highways.
4. Miles traveled on ordinary town roads.

A tabulation of the above information shows that 48 per cent of the farmer's total travel was on the state trunk highways or primary system; 29 per cent on the county trunk or secondary system; and the balance, 23 per cent on the ordinary town roads.

Fifty per cent of the motor vehicles in this average agricultural state are owned in the cities and villages and not less than 80 per cent of their travel is on the primary system. This would result in 64 per cent of the total travel being on the primary system and the balance of 36 per cent on other roads. This shows plainly that a proper distribution of the motor vehicle revenue expenditures must be made if we wish the whole people in the average state to be in general satisfied with the plan.

Assuming that 25 per cent of the 5,600 mile primary system now contains a satisfactory surface, to construct the balance, or 4,200 miles, with a high type surfacing, at $35,000 per mile, will cost approximately $150,000,000.

Assuming also that 25 per cent of the secondary system contains a satisfactory light surfacing, the remainder to be constructed with such would be 6,000 miles. This 6,000 miles would, in many instances, require only a light surfacing of gravel and would probably average not more than $8,000 per mile, or approximately $50,000,000. This would result in a total construction cost of $200,000,000 to complete the improvement of both the primary and secondary systems, containing 13,700 miles, or 17 per cent of the total mileage, which will adequately serve more than 80 per cent of the population of this average state.

There is a limit in almost every state as to the amount of highway construction that can be performed annually at a reasonable cost. The necessary materials and their delivery, the engineering organization rquired by the state department, and the contractors' organizations necessary to execute the work must be taken into consideration. I believe, therefore, that in planning the completion of a program as outlined above, the construction should be spread over at least a ten year period, which would result in constructing 300 miles of high type surfacing and 600 miles of light type surfacing annually, which I believe is as large a mileage as this average state can plan and construct at minimum cost and provide the necessary funds on the "Pay As You Go Plan."

It might be interesting to know that, to construct 300 miles of 18 ft. concrete highways would require 20,000 carloads of coarse aggregate, 10,000 cars of fine aggregate, and 4,500 cars of cement.

To construct 600 miles of gravel roads would require 48,000 cars of gravel.

In addition to the construction program, the mlileage of both the primary and secondary systems should be adequately maintained from the beginning. The annual maintenance cost on the primary system would probably average $350 per mile for the ten year period,

or $1,960,000, and on the secondary system $300 per mile, or $2,400,000, resulting in a total annual maintenance cost of $4,360,000. This annual maintenance expenditure would, of course, include many miles of light gravel surfaces, where gravel is available in order to make roads serviceable until such time as the final surfacing could be financed.

The revenues from the annual increase in motor vehicles owned and operated in this average state for the ten year period will more than pay the maintenance cost.

This average state's share of Federal Aid funds will approximate $2,000,000 annually. This amount, together with the revenue from the 600,000 motor vehicles at $30 each, would produce a total of $20,000,000 annually, which, in ten years, would complete the two systems, resulting in a total of 5,700 miles of high type surfacing and 8,000 miles of light type surfacing.

If each motor vehicle owner will analyze his own case thoroughly, he can readily see that he would be money ahead at the end of the ten year period if he pays the difference between what he now pays and the average of thirty dollars, due entirely to the saving in the cost of operating his motor vehicle, say nothing about the added convenience and pleasure of having a satisfactory system of highways to use. In fact, he cannot afford to do otherwise.

Should this average state authorize the issuance of bonds for the purpose of financing the same program and spread the payment over a 20 year period, it would be impossible for them to construct the entire system in very much less than a 10 year period, due to the time required to plan and execute the work and the delivery of the materials required.

The annual interest charges would increase the total cost of the system by approximately 50 per cent. While it would ease off the annual payment somewhat by being spread over a longer period of years, nevertheless, at the end of a ten year period there will probably be just as many highway obligations facing us as there are today. We find that a highway constructed ten years ago, considered very adequate at that time, is wholly inadequate today, and the highways built ten years ago are either being widened at a cost equal to, if not greater than, the original cost, or are being entirely reconstructed with a pavement two or more times as wide as the former one, with better alignment, better grades and the elimination of all dangerous features as far as possible. The same conditions may not prevail ten years from now if an adequate highway system is planned and completed in this average state, but it is a fact that no American state has as yet permitted their highway department to plan and construct a system of highways that is satisfactory from ten to twenty years after the system's completion.

The motor vehicle owner must not get the idea that if he is taxed to construct this system of highways that his obligation ceases as soon as the system is contructed. The maintenance cost of the system must be paid annually, and it must be provided from the same sources. Therefore, the maintenance cost, plus the additional obligations that the system will entail from year to year, will necessitate the expenditure of not less than the amount of motor vehicle revenue required to construct the system as outlined, spread over a ten year period.

Going back to the cost of owning and operating a motor vehicle in this average state, which is estimated at $455.00. The cost of providing a track for the motor vehicle to operate on, we find is only six per cent of the total cost of owning and operating the vehicle. This small sum cannot in any way be considered a determining factor in purchasing a motor vehicle. If you are willing to expend $455.00 annually to own and operate the vehicle, the additional $30.00 required to construct the surface to operate on at a minimum cost per mile is surely a good investment.

The fact that the motor vehicle is now about the only user of our highways makes it impossible to finance a highway system by any other method than increasing the motor vehicle revenues. If the users of the highways desire a satisfactory highway system in this average state within a reasonable period of years, the only sure method is for them to get behind a plan whereby the revenues derived from motor vehicles will be fixed at an amount that will annually produce the necessary funds to bring about the desired results in a ten year period as outlined above.

Just as soon as the average state makes provisions for an annual revenue sufficient to carry out a moderate program of highway construction and maintenance, sentiment will immediately develop in

certain communities to advance the construction planned for them if possible. The law should be so framed that the local units of government could, if they desired their improvement immediately, anticipate portions of the annual revenues by bonding and using the future revenues to retire the bonds, they paying the interest for the advance use of the roads.

In many instances funds will be made available locally by direct taxation to insure completing worthy projects in advance of their normal time, all of which is operating under the pay as you go plan.

Where a steady though moderate revenue is provided for highway improvement which avoids the uncertainty of legislative action, the highway department can place in effect a budget system for a long term of years, determine that a certain road can be maintained with the funds available until a certain year and provide the funds at that time for its construction. A moderate steady plan of highway construction on the "Pay As You Go Plan" is far better for the material producers, transportation lines, contractors, engineering department, and, in fact, everyone financially or otherwise interested. It stablizes the whole operations, permits ample time for properly planning the work, and prevents the state from being flooded with "hay-wire" contractors and "mushroom" material producers.

To construct a system of highways under the "Pay As You Go Plan" requires entire freedom from political control of funds. All sections of the state must be treated fairly and each year's funds be expended where most needed, traffic and other conditions taken into consideration.

Sentiment for more and better highways must be promoted religiously; in other words, the general public must be kept "coming." It is a false idea that prevails in some states that the temporary improvement of earth or gravel roads is a waste of funds. Every time an earth road is smoothed up by dragging or grading, it creates sentiment for a surface road, and when a gravel road is constructed, it whets the appetite of the users for a higher type surface.

A child must creep before it walks, and sentiment for high type surfacings must be promoted in many instances by the construction of lower type surfaces to serve traffic temporarily.

A large percentage of the back-bone of this average state lives on the secondary highways and must be reckoned with in planning a highway system. Any plan that does not take into consideration the interests of the motor vehicle owners living in the agricultural sections, and especially on the secondary highways, is not fair and cannot be justified. When the vast majority of the small town and agricultural residents are satisfied with a plan of highway financing and improvement, then, and then only, is when this average state can continue to construct and maintain a real highway system with satisfaction to all. This can be accomplished with less friction by adopting the "Pay As You Go Plan" and:

First, provide for an annual motor vehicle revenue sufficient to construct within a 10 year period and annually maintain a highway system containing at least 15 per cent of the total highway mileage of the state.

Second, furnish immediate highway service on this entire system by installing a thorough patrol maintenance system regardless of whether or not the roads have been surfaced or otherwise improved.

Third, where available, apply a light surfacing of crushed stone, gravel or other suitable material in advance of the final contemplated surfacing in order to get traffic "out of the mud" at the earliest possible moment.

Fourth, construct at least the primary system with a high type surface as rapidly as funds can be provided from the annual revenues. This should not be done at the expense of the secondary system. Give each their proper share of funds according to traffic requirements.

Fifth, and last, but not least, direct traffic by adequately marking and signing the whole system. This is a necessary factor to be considered when financing a highway system.

Under the plan as outlined, this average agricultural state will have a very satisfactory highway system from the very beginning and a real system at the end of a ten year period. There will be no future obligations in the form of bond retirements and annual interest charges. Every dollar of the motor vehicle revenues from year to year will be expended in construction and maintenance of the highway system. This can truly be called a "Pay As You Go Plan" of highway financing.

ASPHALTIC PAVEMENTS ON OLD MACADAM OR GRAVEL BASES IN GRAND RAPIDS, MICH.

By C. A. Paige, City Engineer, Grand Rapids, Mich.

(Paper presented at the Fourth Asphalt Paving Conference, Detroit, Mich., Oct. 21-23, 1925.)

In 1910, Grand Rapids laid its first asphaltic concrete pavement over an old macadam base. This was on East Fulton St. from Jefferson Ave. to Union Ave. East Fulton St. carries the bulk of the east bound traffic from the business section and is a part of State Trunk Line 16 into Detroit. In spite of the ever increasing traffic, it has had to bear, the pavement is in fine condition and is slowly wearing away as is shown by the elevations of the castings.

In 1912, a Topeka mix pavement was laid on Plainfield Ave. from Quincy St. to Ann St., a distance of 2,500 ft. This pavement was laid on an old gravel base, which was built up where necessary with crushed stone. This pavement is a link in State Trunk Line 13 and carries north bound traffic to the suburbs. The pavement is in perfect condition and good for many years.

Monroe Avenue from Newberry St. to Coldbrook St. was paved with 3 in. of sheet asphalt in 1915 over an old water-bound macadam street. The street was worn down to the cobble base and the asphalt was placed directly on the cobble. This asphalt pavement has had an enormous amount of heavy traffic for ten years, but is in perfect condition.

Practically no more pavements were laid on bases of this nature until 1920 when the department decided to lay a 3 in. asphalt pavement on the better class of gravel streets, using the present roadway as a base.

Perhaps a short explanation as to how these gravel streets were constructed would be in order at this point. In 1897, the Engineering Department improved their methods in the construction of gravel roadways. Prior to this time the roadways were built up in two layers, 6 in. of bank gravel with a 6 in. layer of screened gravel. The gutters on these streets were invariably cobble stone and generally without vertical curb.

In the above named year, the specifications were changed so that the gravel roadways were built up in four layers. The bottom layer was composed of either cobble or large gravel filled in with 1¼ to 2 in. gravel and thoroughly rolled using a clay binder. The succeeding three layers were composed of 1¼ to 2 in. gravel thoroughly compacted and bound with clay. All gravel was clear of sand and the clay was as pure as could be obtained. The result was a hard gravel pavement of from 10 ins. to 12 ins. in thickness.

The curb and gutters were built with these improvements and consisted of separate curb with 3 ft. brick gutter or combined curb and gutter (18 in. concrete gutter) bordered with 18 ins. of brick gutter. The construction of all gravel pavements was discontinued in 1918.

In 1920, Grand Rapids had about 70 miles of this type of gravel road which was becoming almost impassable from the development of chuck holes. They could not withstand the increased automobile traffic and the maintenance cost was beyond the department's funds.

Four streets of the above type were covered with a 3 in. sheet asphalt top in 1920, our first real venture in this type of paving.

Herewith is a table showing the amount of this kind of work Grand Rapids has done to date.

THREE-INCH SHEET ASPHALT PAVING ON GRAVEL BASES

Year	Number of Contracts	Sq. Yds.	Miles
1920	4	8,504	0.651
1921	2	6,270	0.372
1922	11	53,354	4.003
1923	16	68,632	4.610
1924	16	84,246	5.544
1925	9	41,297	2.779
Totals	58	262,303	17.959

In preparing the gravel roadways for the asphalt top, the street is scarified with a steam scarifier attached to and a part of our steam rollers. This operation loosens the top layer of gravel, which is hauled from the street, only enough being saved for filling, where necessary, at the time of the subsequent rolling. The street is then thoroughly rolled with a ten or twelve ton roller and brought to the proper grade to receive the 3 in. asphalt top. The street is then allowed to dry and the asphalt is applied as on a concrete base.

The gravel street when the rolling is finished and the street dry gives us a hard durable base, capable of withstanding the present traffic conditions if sup-

plied with a suitable wearing surface which is furnished by the asphalt.

Some old streets are so badly worn away that very little scarifying is necessary and new material is needed to bring it to proper grade to receive the top.

If the old street was built with 3 ft. brick gutters, these are preserved and have some penetration streets built in the asphalt built up to these gutters. Any bad depressions in the old gutters, are eliminated by relaying the brick and the finished street left in proper shape for good drainage.

Where the street has combined curb and gutter with an 18 in. brick border, these bricks are removed and the asphalt laid up to the remaining 18 in. concrete gutter. Any defective curb and gutter is replaced with new and again the street is left properly drained.

It has been our experience that, when asphalt is laid on a concrete base, cracks invariably develop in the concrete at certain space intervals. These cracks immediately show up in the asphalt top and are a source of annoyance. They are not, perhaps, a serious defect to the pavement, but are a topic of criticism for the average property owner.

The gravel base has no apparent expansion or contraction—at any rate there is no movement great enough to cause cracks and develop inperfections in the asphalt top.

In all the yards of asphalt that Grand Rapids has laid on this type of base, I believe I can safely say that not one opening has developed from a base crack.

There are other points in favor of this type of pavement which should not be overlooked. Let us consider the cost of this pavement and speed in finishing as compared with one on a concrete base.

If the gravel street were graded to a sufficient depth to receive a concrete base, the extra cost of excavation would amount to about $0.15 a square yard. The concrete base costs us $1.10 per sq. yd. So, by utilizing the present gravel as a base, we save the property owner $1.25 per sq. yd. or from $1.50 to $2.00 per front foot of property, depending on the width of roadway.

The gravel street is speedily prepared for the asphalt top and with but slight inconvenience to the public. There is no delay in waiting for the curing of the concrete and the public is permitted to drive on the gravel base as soon as it is dry and until ths asphalt is applied.

The majority of these pavements are laid in the residential districts, where most of the gravel pavements were built. We have one in particular, however, which is in the down-town district and carries a large amount of traffic. This pavement is in fine condition and has satisfied us that this type of construction is the proper answer for salvaging the gravel roadway.

THE COST OF INADEQUATE STREET LIGHTING

By Charles J. Stahl, Manager Illuminating Engineering Bureau, Westinghouse Electric and Manufacturing Co., South Bend, Ind.

The realization of the excessive costs of inadequate street lighting has brought about a rapidly increasing number of street lighting installations. Seldom are human emotions aroused to the extent of producing action by mere reference to the cost of any project, but place before them the enormous sums that are expended year after year in payment for inefficient operations and you have struck a vulnerable spot.

Only 73 years ago homes were lighted with sperm oil. The average home then used 25 candle hours per night, or 9,000 per annum, costing approximately $24. Today the average home uses a little more than 20 times as much at about the same cost. In other words, we have increased 20 times in the last 70 years, whereas we hardly doubled in all the preceding ages. In street lighting we have had approximately the same rate of progress, but the necessity for the artificial illumination of streets has increased, whereas in the home our needs are essential the same as 50 or 100 years ago. More urgent need for the adequate lighting of our streets has come about, as we all know, by the enormous increase in the volume and speed of street traffic. We do not immediately appreciate the benefits of good street lighting in relation to this traffic and we do not know it all yet, but we are beginning to realize that nationally we should have a better economic balance between the cost of street lighting and the needless losses resulting from its inadequate use. In the Cost of Adequate Street Lighting it was pointed out that no specific formula for the determination of adequate costs be prescribed. Conditions are, of course, not the same in all communities. The costs of providing street lighting services vary. The style of equip-

ment preferred varies. In all cases the purposes for which street lighting is desired are fundamentally the same, but they sometimes vary in rank as to order of importance.

On the other hand, the cost of inadequate street lighting does not vary greatly. Where we have traffic of given volume, speed and density, there is natural inevitable traffic accidents hazard and loss until we bring to bear what influence we have in the form of traffic control and street lighting, and then there is still some loss, but not so much.

We do not know exactly what our national cost of inadequate street lighting is, but some pretty well-founded estimates have been made. It is easy enough to appraise the cost of replacing a wrecked automobile in apparently first-class condition, but we cannot evaluate the economic loss to the community and society as a whole when on a poorly lighted street a preventable accidental fatality occurs.

From an analysis of accurately compiled statistics on traffic accidents in many of our larger cities, it was determined that a certain percentage were directly attributable to inadequate street lighting. This percentage, applied to the record for the entire United States and evaluated on a logical economic basis, showed a total preventable property accident loss of more than $50,000,000, which is more than the present annual expenditure for all street lighting in the United States. This takes no account of the life hazard.

We have been thinking in terms of the cost of street lighting, and this is natural, for we must speak in terms of cost in building budgets, and budgets grow without much of a building effort. However, if we will at times stop to consider the cost of inadequate lighting, we shall be able to reach a better economic balance for determining in what measure funds should be allotted to street lighting.

I have mentioned only the item of traffic accidents. There are equally definite figures showing the potentiality of street lighting in crime reduction. Statistics on this phase of the subject have been presented a number of times and need no elaboration. I do not know of any effort so far made to determine in dollars and cents what actual saving could be effected in this direction.

These, in conservative judgment, are some of our costs of inadequate street lighting, and fortunately good street lighting is gaining popularity at a very rapid rate. In some cases this growth does not spring from a calm scientific appraisal of its worth, but is rushed as an emergency measure to ease distressing conditions of traffic and crime. Improvements so found are not always handled to best advantage. Many economies are assured through advance planning. Street lighting plans should run far in advance of immediate requirements. In past years the usual practice has been to confine street lighting improvements to limited sections. Just as city planning has in the past been almost wholly confined to scattering about the city a few beauty spots, such as civic centers, parks and playgrounds, so has street lighting been scattered through the agency of localized improvements carried out as private developments or in the form of improvement districts. Nearly always the aim has been to boom a restricted area to commercial leadership through the establishment of "White Ways." The work of so-called improvement districts may be made valuable if regulated under a general improvement plan, but without centralized command the result is haphazard patchwork.

A scientifically derived, comprehensive and far-sighted street lighting plan correlated with a city zoning plan is not easily worked out, but it is worth the effort.

The expenditures necessary for good street lighting can be justified by available traffic and crime statistics. There are, however, other benefits which we fail to enjoy where the lighting is inadequate. In residential areas the feeling of safety, comfort and convenience is worth the cost. Real estate promoters know that it increases property values. At Tampa, Fla., a large real estate operator wished for an island in the bay just off shore from the business section. He contracted for the largest real estate street lighting project on record and presently the island appeared.

Good street lighting presents to the entire public very conspicuous and easily understood evidence of the administration's good works in the community, and we now have a pretty well cultivated taste for civic beauty. In street lighting, like in many other works, we have had too much temporary construction, instead of planning for the required flexibility along with permanence. There are a great many ornamental and permanent street lighting installations to be designed and built. They can be made to express art

and the master's stroke in works of permanence. The present trend is not only for more adequate street lighting, but for comprehensive advanced planning and for construction of a type which in a measure parallels the cathedral in both art and permanence.

WORK OF AMERICAN CONSTRUCTION COUNCIL

The address of Hon. Franklin D. Roosevelt, President of the American Construction Council, at its fourth annual session, on Nov. 18, 1925, follows:

Representing through the Council all the component parts of a huge six billion dollar industry, which has this year broken all previous records in volume of activity, our common conference table should produce results of the greatest benefit to the entire nation.

This, after all, is the American construction movement—that progressive measures on the part of the construction industry shall be taken, and that its ills, when they exist, shall be cured not by governmental and court action, but by the voluntary work of the industry itself. It is this that marks the movement as one of the big forward steps in American industrial organization.

Too few persons visualize in a practical manner the vastness of construction and its importance in promoting the economic prosperity of the country. Moreover, many who believe this in principle do not adhere to it in every day practice through the adoption of methods that make for sound development throughout the industry. Construction, unlike many other industries, both creates and maintains wealth. How this wealth is created determines how well it can be maintained. Knowledge and responsibility must go hand in hand in securing the desired results and they cannot go hand in hand unless the many branches of the industry work together on problems of mutual interest.

The American Construction Council was formed to unify the industry not only in public and official thought but in its actual operation. Its field of service embraces construction in all its many phases —highway construction, transportation systems, power plants, and the like, as well as building construction.

Our power in dealing with those many phases of construction in their relation with the public is that of common counsel and cooperation on the part of all the component parts of construction—from investors, producers and distributors, transportation agencies, architects and engineers, surety and real estate men, constructors, labor and public officials actually engaged in construction operations, to the allied industries of distribution and commerce that feed construction and are in turn fed by it. The enormous influence to be exerted upon both the industry itself and the public through properly directed cooperation merits the earnest endeavor of us all.

As I had occasion to say just a few days ago in a statement to one of the branches of the industry, after three years' association with the American Construction Council which was organized by Secretary Hoover and myself, I am more and more convinced of the need for cooperation in the whole construction industry. Two points I would stress. The construction industry is a whole, and we have learned what was not generally understood a few years ago, that the thousand parts of the industry are component and lean on one another for success. In the old days there was too much tendency to feel, for instance, that those interested in steel construction were necessarily antagonistic to those interested in wood construction; that brick manufacturers are merely rivals of the cement makers. Today, however, we know that in construction as in so many other human activities, what makes for the good of one is apt to make, also, for the good of others. In other words, there is plenty of room for all if the industry as a whole is on a sound basis.

The American Construction Council seeks to bring together these component parts of a great whole at its meeting held twice every year, and to bring about cooperation towards ends which will serve the industry as a whole. We have, for instance, assisted and encouraged the national effort to end as far as possible, the seasonal features of building to eliminate the peaks and valleys, and to encourage construction operations spread throughout the year.

To assist along these lines the Council in accordance with resolutions adopted at its Spring meeting is forming jointly with the American Railway Association, a general co-ordinating committee which will include representatives of appropriate branches of the industry for the purpose of conducting a unified campaign of pub-

licity for the country as a whole on the elimination of construction peaks and depressions.

The Council has been engaged for several years in a co-operative campaign to encourage better building, having been the leader in this movement nationally. As an economic factor in our national life, the losses from poor construction, plus the appalling losses from unnecessary conflagration would have paid the whole war debt of the United States and most of the European nations.

The response from both the industry and the public to these efforts to promote sounder financing and better quality of construction has been most gratifying. Perhaps no other movement has received such enthusiastic support from the press of the country including editorial approval as has this. If the Council had done nothing else to the present time, it would have justified its existence many fold.

In the last analysis the answer and the remedying of present conditions must be two fold. The construction industry itself must work together instead of at odds with itself, and under its leadership the public of the country must learn the essentials of right construction. It is, after all, not the steel men nor the brick men nor the lumber men, nor the masons, nor the carpenters, nor the plumbers who are, the constructors of modern homes in America. It is the general public in their homes, in their factories, in their transportation who decide when to build and how to build.

If this co-operation of the industry as a whole which is so essential to real leadership is to mean what it should it is obvious that the many different branches of the industry itself must be properly organized and equipped to carry out their respective functions, as some have already been endeavoring to do for example in working toward the elimination of certain wasteful methods. Then the entire industry with a united voice can reach the public in such a way as to focus an informed opinion upon its problems and thus secure the full measure of benefit that the public, in common cause with the industry, should receive.

I should therefore like to picture to you the Council as a great educational and publicity force for the industry as a whole in reaching the public with regard to its problems. Its efforts along these lines should not be confined merely to particular problems, such as Better Building, reduction of construction peaks and depressions, better highways, commercial arbitration and the like, important as these are: but they should center with these particular problems in the foreground, toward the development of the real concept of construction in the mind of the public. The lack of clear understanding by the public of the construction industry as an industry is the basis of its many difficulties. Certain research functions would naturally accompany this program of education. I am directing the attention of our governing body to consideration of ways and means of securing adequate support for this nation-wide movement.

Being impartially constituted, non-profit making, and made up of all those interested in any way in construction, the Council can handle these problems in their national phases much more effectively than any other agency in the industry and without its efforts being discounted on the basis of private gain. But at the same time it does not interfere in any way with the furtherance of proper trade interests by the respective branches of the industry.

In this connection I might recall that the Council has recently adopted a number of policies of far reaching importance in broadening its field of active service.

To help bring its work into closer contact with the various districts of the country and to make it more responsive to their needs and desires, it has already established a number of regional committees covering areas paralleling in large measure the leading Federal Reserve Banking Districts of the country and the plan looks ultimately toward establishing them throughout the country. As a phase of this movement to keep in the closest possible touch with the different parts of the country, the policy has been adopted of holding the Council's meetings in the various leading cities of the country. In line with this policy our annual meeting is being held this year in Chicago.

In conclusion, the work of the Council, I am happy to say, is going forward in a very gratifying manner recognizing that its services from their very nature are sometimes intangible. But they are none the less real in bringing results that are translated into dollars and cents for all those who have a legitimate part to play in construction or are in any way interested in it.

RESOLUTIONS OF STATE HIGHWAY OFFICIALS

Following are the resolutions adopted at the Eleventh Annual Convention of the American Association of State Highway Officials at Detroit, Mich., Nov. 18, 1925:

Favoring Continued Federal Aid

Whereas, The appropriations now authorized by Congress for the purpose of carrying out the provisions of the Federal Highway Act do not extend beyond the fiscal year to end June 30, 1927; and

Whereas, Appropriations beyond said fiscal year 1927 should be authorized for such periods in advance as to enable the State highway departments so to plan their construction as to best utilize such appropriations when they shall become available; now, therefore, be it

Resolved, That it is the sense of this Association that Congress at its ensuing session should authorize further appropriations for said purpose for the fiscal years to end June 30, 1928 and 1929, respectively, and that the appropriations so authorized should be at the rate of eighty million dollars for the co-operative construction of rural post roads and eight million dollars for the construction of forest roads for each of said fiscal years 1928 and 1929.

Opposing Reduction of System of Federal-Aid Highways

Whereas, The system of Federal-aid highways selected and designated by the highway departments of the several States and approved by the Secretary of Agriculture of the United States pursuant to the provisions of Section 6 of the Federal Highway Act, embraces those highways in each state, selected after careful study, which will provide a properly correlated and connected system and best accommodate local and farm to market traffic as well as state and interstate traffic; and

Whereas, Any reduction in said system of highways as now selected and approved would tend to break the continuity of said system and might so restrict the same that many communities served by highways now rightfully included therein would be deprived of such service; now, therefore, be it

Resolved, That this association is opposed to any plan which has for its purpose a reduction in the system of Federal aid highways as now provided for in Section 6 of the Federal Highway Act.

Approving Uniform Marking System

Be It Resolved, That we express appreciation for the work of the Joint Board appointed to select a system of transcontinental and intersectional highways to be uniformly marked and equipped with uniform safety devices and also for the valuable co-operation given said Board by the Bureau of Public Roads.

Favoring Increase Limit Per Mile on Federal Roads

Be It Resolved, That the bill (H. R. 6133, 68th Cong. 2nd Ses.) introduced in Congress by Hon. Don F. Colton, of the State of Utah, as amended by the sub-committee of the Committee on Roads of the U. S. House of Representatives and embodied in the report of said sub-committee to the full committee under date of February 13, 1925, is approved by this association and its passage urged upon the Congress, except that it is the sense of this association that said bill should be amended to change further the limitations on the payments of Federal funds per mile which the Secretary of Agriculture may make so as to permit the Secretary of Agriculture to make payments above said limitations per mile in the case of any project which, by reason of density of population or character and volume of traffic, the State Highway Department and the Secretary of Agriculture may determine should be improved with a surface of greater width than 18 ft.

Urging Uniform Directional Signs

Whereas, It is generally recognized that uniform directional signs and safety devices will greatly facilitate and safeguard traffic upon our highways; now, therefore, be it

Resolved, That this association urges that each State, county and township erect upon the highways under their jurisdiction, respectively, uniform directional signs and safety devices approved by the State highway departments and the Federal Government.

Expressing Satisfaction With U. S. Bureau of Public Roads Co-operation

Whereas, We are approaching the close of the first decade of co-operative road construction work conducted by the States and the Bureau of Public Roads of the U. S. Dept. of Agriculture under the provisions of the Federal-aid road act of July 11, 1916, and acts amendatory thereof; and

Whereas, Public roads constitute the primary means of transportation for agri-

culture, our largest single industry, now, therefore, be it

Resolved, That the American Association of State Highway officials, after ten years' experience in co-operative work with the Bureau of Public Roads as it functions under the supervision of the Secretary of Agriculture of the United States, hereby expresses complete satisfaction with the manner in which said Bureau has conducted its co-operative work with the States and commends the spirit of friendly helpfulness and the desire for increased administrative efficiency manifested at all times by the Bureau of Public Roads in its relations with the States.

Urging Uniform Forms for Contractors

Whereas, The Executive Committee of the American Association of State Highway Officials on May 23, 1925, received and approved the report of its Committee on Co-operation with Contractors, recommending the uniform use of standard questionnaires as recommended by the Joint Conference on Construction Practices; and

Whereas, The letter ballot authorized by the Executive Committee approved said forms; and

Whereas, Your Committee on Co-operation with Contractors feel the uniform and definite use of said questionnaires will greatly assist the State highway officials in dealing with contract problems; therefore, be it

Resolved, That we urge the prompt adoption and uniform use of the forms by the various States.

Commends Grade Separation Plan of New York State

Whereas, The State of New York at the recent election, by popular vote authorized a state-wide policy of railroad grade crossing elimination, and the funds necessary to carry on a large and continuous annual program which will wipe out three to four thousand dangerous crossings; be it

Resolved, That this Association record its deep interest in this advanced public policy and extend to Gov. Smith, the State Highway administration, and the people of the State, its sincere approbation of the successful outcome of this very important issue.

Recommends Adequate Salary for Chief of Bureau of Public Roads

Whereas, The improvement of highways is now a major activity of the State and Federal governments, involving the expenditure of stupendous sums of public funds each year; and

Whereas, The efficient and economical administration of the public funds provided for that purpose requires that the chief executive officer of each State and of the Federal Government charged with the responsibility of administering said funds shall possess technical and executive ability of a high order and should receive a salary commensurate with such responsibilities; and

Whereas, The salary of the Chief of the Bureau of Public Roads is less than that received by the Chief executive officer of the highway departments of many of the States; therefore, be it

Resolved, That it is the sense of this Association that the salary of the Chief of the Bureau of Public Roads should be substantially increased and it is urged upon the Congress that such action be taken as may be necessary to accomplish same.

DATA ON MOSQUITO CONTROL METHODS

(Editor's Note: Following is the full text of the report of the Committee on Mosquito Control, Sanitary Engineering Section, American Public Health Association, presented at the annual meeting of the Association at St. Louis, Mo., on Oct. 19-22, 1925. Mr. L. E. Jackson, Executive Secretary of the Hudson County Mosquito Extermination Commission, Jersey City, N. J., is chairman of the committee).

Mosquitoes were unusually rampant in practically all sections of the country during the past summer. The chief cause was the weather, which greatly favored their production. There was enough rain in the North and West to provide ample breding places and long periods of humidity to favor the rapid production of the insects. The lack of rain in the South, however, intensified sewage pollution of streams resulting in a marked increase in Culex production.

Observations in New Jersey developed the striking and disturbing fact that one result of such wet, humid weather was that the life cycle of two or three species of mosquitoes was found on several occasions to have been reduced from the usual warm weather period of seven or eight days to five days, which further complicated matters. It was evidently a so-called insect year as flies, moths, and many other kinds of insects were reported

in enormous numbers very generally throughout the country. One lesson of this trying season is that to satisfactorily meet such an emergency, mosquito fighting units must be so organized as to provide for the greatest possible expansion.

In its investigations of progress in mosquito control throughout the country your committee has assembled the following data which is submitted for your information:

1. Operations were carried on very generally in 11 states.

2. Activities in a limited degree were reported in 10 states.

3. No control whatever has been undertaken in 27 states.

Included in the first group are the following states with a brief description of the principal features of anti-mosquito work:

New Jersey

The control work in New Jersey which has been thoroughly organized for sometime was continued this year along the same general lines as heretofore. The total amount of money expended for the year will be about $325,000, approximately the same as the preceding year. The most outstanding feature in the work in New Jersey during the past two or three years is the development of machinery for certain drainage operations. This year the construction of a ditch cutter was completed by the State Experiment Station which is designed to cut the regulation straight-sided ditch adopted as the standard in that state. The cutting and tractor units are combined with one power plant of 45 horse power. A 5-ton Holt Tractor was remodeled so as to provide caterpillars with 4-ft. treads and a 15-ft. wheel base upon which the cutting device is mounted. The cutting is done by 36 steel buckets carried on an endless chain belt. The sod removed is chewed up and spread overan area 30 ft. in width which it is claimed will prevent blockage often occurring by sods being washed back into the ditch. The usual chain drive has been improved upon by the installation of a direct steel gear drive of great strength. The total weight of this sturdy machine is 12 tons, but it is interesting to note that the ground pressure is only 1½ lbs. per sq. in., which is about equal to that of a man of average weight. The machine is so sensitive that it can be operated by one man although the use of two is planned. Experiments indicate a speed of 40 ft. per minute and the cost per foot per ditch cut as somewhat less than ½ ct. as compared with 1½ cts. for the type of machine now in use and 3 cts. for handwork. It can readily be seen that great economy will be effected with the saving of approximately 70% in the cost of ditching and an increase in the number of feet cut. The cost of the experimental machine was $10,000 but it is believed that it can be reproduced for about $8,000. The official test of the machine will be held in the early part of November.

There has been no change in the design of the ditch cleaning machine, but certain refinements have been worked out by the designer recently involving the more extensive use of steel. The improved machine will probably cost between $4,000 and $4,500. The use of the machine in cleaning work, however, will effect a great economy even at that price. Machines were successfully operated in the season just closed in five counties in New Jersey.

In relation to methods of raising funds for mosquito control work, it is interesting to note that the State law, under the provisions of which control operations are carried on by county units, which statute has been widely discussed as being a model of anti-mosquito legislation, was recently supplemented by the passing of an act enabling county Boards of Freeholders to bond a county when the need exists up to the sum of $300,000. The Chamber of Commerce of one county in which work has been backward is supporting a movement seeking the appropriation of $200,000 under the terms of this act for the purpose of completing salt marsh drainage.

Florida

Considerable interest in mosquito control work has been shown in Florida. The Florida Anti-Mosquito Association succeeded in getting a bill passed at the last Legislature enabling any community to organize a mosquito control district. The Bill is similar to those in vogue in New Jersey and California. Two communities in the State are preparing to avail themselves of the provisions of this new act. There are several cities engaged in anti-mosquito control work, although interest in the State as a whole has somewhat subsided for the present owing to the tremendous activity in real estate. Thousands of acres of swampy and low lands have been reclaimed by hydraulic fill methods during the past year. The present land development programs of neces-

sity include thorough drainage and are perhaps doing more for the actual control of mosquitoes than all the educational propaganda formerly promulgated.

Mississippi

In Mississippi there are some 40 towns engaged in anti-mosquito operations, principally from the standpoint of malaria control, although considerable activity is directed against the pestiferous mosquito also. The highest death rate for malaria obtains in this state, but a marked reduction of malaria has resulted from the work in several counties. There are 12 active full-time county health departments engaged in mosquito work.

Texas

In Texas, in addition to the border campaign, many towns are doing mosquito control work. The state department of health has an appropriation of $10,000 for this work, supplemented by outside agencies. The Engineering Division directs the work through an expert, who organizes local forces for surveys and actual operations, under municipal ordinances made for the purpose, which are financed by each locality. With this procedure more or less intensive work is carried on in over 100 communities, resulting in a very material reduction of malaria cases. The top-feeding minnow is also used extensively. In order to obtain the maximum of efficiency in the work a school of sanitarians is held each year, the attendance at a recent four days' session of which was 500; 36 towns employ whole-time inspectors and in 62 towns part-time inspectors are engaged in the work.

The Cotton Belt, the Missouri Pacific and the Rock Island Railroads are working in co-operation with cities and towns along their lines in malaria mosquito eradication campaigns. With the development of these plans practically every railroad west of the Mississippi in Texas, Arkansas and Louisiana will be conducting campaigns of their own or supporting the health authorities in this work. It is interesting to note that an anti-mosquito demonstration was conducted under the joint auspices of the Missouri Pacific Railroad, the Arkansas State Bankers' Association and the State Board of Health, thus securing the co-operation of the banking and agricultural interests.

The following information in relation to the "Mexican Border Campaign" was furnished by Col. Joseph A. Le Prince, Senior Sanitary Engineer, United States Public Health Service, who directed that very excellent work: The operations included 68 villages and towns in the triangular area between Brownsville, Del Rio and Corpus Christi. The problem was the control of mosquitoes breeding in containers to prevent "stegomyia" production. It included the inspection of 108,500 premises where 16,800 barrels were used for water storage; 64 per cent of them were eliminated and 86 per cent of those remaining were protected against breeding; 5,800 cisterns were under inspection, of which 73 per cent were protected permanently against breeding. In May, 1925, less than 1 per cent of all containers were producing any kind of mosquitoes.

As you no doubt know, this border campaign was conducted for the purpose of preventing yellow fever from entering the United States from the fever-ridden country to the south, and was a striking success.

Alabama

In Alabama control work has been under way for 10 years, organized largely through County Health Officers. In 1922 regulations affecting the impounding of water were passed and have been rigidly enforced. Control work has been carried on in 23 counties. The cost in 1924 was $33,000; 1,100 places were stocked with top minnows. Extensive educational campaigns were also carried on. It is interesting to note that the Muscle Shoals pool covers an area of 17,500 acres and is under control. A larger one with an area of 38,800 acres is under construction.

Forty cities and towns in Georgia are doing malaria control work, with additional activities in certain rural sections.

The states included in the second group have shown only a minor death rate from malaria in recent years, except in the case of Kentucky.

There is a limited personnel attached to the Board of Health in Kentucky and their attention is directed to intestinal diseases rather than to that of malaria.

In Massachusetts control operations have been carried on for a number of years in certain sections by the Massachusetts Society for the Control of Mosquitoes, embracing educational measures conducted with the idea of eliminating the house mosquito. Some salt marsh work was done, the most notable of which was on Cape Cod, in a fight to control mosquitoes said to assume fantastic proportions.

Anti-malaria work was carried on in three communities in Maryland with satisfactory results.

New York

In New York state intensive control

has been limited to Nassau County, where the work has been conducted since 1916 by the County Mosquito Extermination Commission along the same general lines as in New Jersey. Excellent results have been obtained, their annual expenditures ranging from $50,000 to $80,000. Inspection and maintenance, both essential to success, are systematically carried on.

In New York City a very limited amount of anti-mosquito work has been done in recent years, due, strange to relate, to insufficient funds being appropriated.

Illinois

In Illinois the 12 most southern counties are considered by the State Department of Health as the "malaria belt." Mosquito control was started by the State Department of Health in 1922 and at the present time there are 12 cities conducting mosquito campaigns. The activities in mosquito control this year have been greater than in all previous years. An intensive campaign, inaugurated by the Gorgas Memorial Institute, which organization made the survey and organized the forces of the several communities in one unit and is directing operations, was conducted this summer in Chicago and its suburbs, with very satisfactory results. The problem there is chiefly one of river and creek breeding on a rather large scale because of the employment of the streams as sewage outlets. House to house inspections conducted by 400 Boy Scouts showed the average of 40 per cent of houses breeding mosquitoes. Extensive control work was done by the Sanitary District of Chicago in the territory under its supervision, at a cost of $25,000. There has also been organized an Anti-Mosquito Board of Metropolitan District, composed of leading physicians and business men. Rather interesting from the standpoint of financing is the information that a campaign for raising funds was put in operation in the suburbs early in the year, with the women selling "A Dollar's Worth of Comfort" in the form of tags telling that the purchaser had contributed to the common cause in the war on mosquitoes.

Virginia

In Virginia there are 25 towns doing control work. The cities of Norfolk and Portsmouth are maintaining the control of breeding in the reserve water supplies. "Anopheles quadrimaculatus," the only vector of malaria in the State, has been found breeding only in ponds. Pond control has been found to be more economic and effective through fluctuation of the level. That is, the water in ponds under control is held at as high a level as possible throughout the winter, and lowering is commenced about June 15. Where good fall is possible 1 ft. is run out, and, when breeding resumes, another foot. Two or three droppings of the pond's surface of a foot each has always given control of "anopheles" breeding.

Missouri

In Missouri the problem of mosquito control and malaria prevention is practically limited to the southeast section of the State. The problem appears to be one of ditch maintenance. Surveys are being planned to prove this point, and if that fact is established it is expected that a campaign will be inaugurated for proper ditch maintenance. A survey of an impounded water project, on which construction work has begun, is being conducted with the co-operation of the United States Public Health Service. It is planned to conduct these surveys on all new projects developed.

A limited amount of work is conducted by the State Experiment Station in Connecticut.

In Rhode Island control work is carried on in several cities and towns, principally in Providence, where operations have been conducted for 12 years, including the establishment of permanent drainage systems. Aid has been extended to the several communities by the State, amounting to $40,000 in 1923 and $20,000 in 1924.

California, one of the first states to take up the fight against mosquitoes, is carrying on control operations in 17 abatement districts. The top-feeding minnow was introduced in 1922 with excellent results.

In some of the states of the third group we find that there is no mosquito problem; in others, Culex mosquitoes are prevalent, and in still others there is Anopheles production, with a consequent slight malaria problem receiving no attention.

It is interesting to note that in response to a growing demand along the Gulf Coast of Texas, Louisiana, Mississippi, Alabama and Florida for freedom from Aedes sollicitans, the Division of Entomology of the United States Department of Agriculture has started the study and investigation of the problem. It is understood that the object of this movement is to make the Gulf Coast country attractive

by freeing it from the mosquito pest, which will greatly enhance property values, as in any community.

Anopheles control, which was started in the South by the United States Public Health Service in 1914, and carried to 13 states, is now being supervised by the State Health Departments. Requests for advisory assistance from incorporated communities have increased to such an extent as to greatly exceed the capacity of the Health Departments in some cases, due to insufficient personnel.

The expansion of anti-mosquito operations in the various sections of the country indicate the favorable tred of public opinion toward the elimination of this offending insect, be she of the malaria carrying species or of the pestiferous branch of the family. In the South, as well as in the North, the principal object is that of conserving the efficiency of the individual and securing the benefit of comfort. In both regions campaigns are inaugurated every now and then and additional communities secure relief from an unnecessary evil.

The mosquito problem in all its phases is so definitely linked with sanitation problems that the sanitary engineer, whether engaged in governmental or industrial operations, may often give an anti-mosquito campaign its inception when he sees the need for control in a community where no initial work has been done. The phase of the work in which his counsel would be especially valuable is that affecting the breeding of mosquitoes on private property, which resulted during the past summer in the emergence of vast hordes of mosquitoes throughout the country.

Another field which, because of its temporary nature, may be overlooked, is that of the tourist and organization camps, increasing in numbers each year in many states. We hear of considerable activity in the prevention of typhoid in such camps, but in the twilight, when the typhoid inspectors have ceased their labors, such a camp may become a popular resort for mosquitoes which have wriggled unnoticed into existence in some near-by pool of clear spring water, a favorite habitat of the malaria-carrying branch of the family.

Educational Work

Assuming that anti-mosquito forces of a community were to eliminate or place under control all the known breeding places, the fight would not be won unless there were obtained the serious co-operation of each individual householder by the elimination of breeding places on his own premises, of the existence of which another would generally have no knowledge. There is, of course, nothing new to you in this fact, but we desire to stress the point for the reason that as mosquito control work advances toward completion, this phase of the subject must be given special attention, and an intensive campaign of education and publicity should be co-ordinated with active operations. The fact that a full measure of relief and comfort cannot be obtained unless he prevents breeding on his property must be emphatically and continuously brought to the attention of the individual.

News articles and talks to a limited number of people are not sufficient. The Committee invites attention to the following by way of suggestion: One medium employed in New Jersey was the showing of a motion picture reel, not to clubs or lectures, but in practically every motion picture house in the State. Another was issuing to the higher grades of all schools of a mosquito manual especially prepared for the purpose. Seeking a new angle with a novel touch, Hudson County inserted a number of display advertisements in the leading newspapers, calling upon every one to clean up breeding places and attaching the slogan, "No Water, No Mosquitoes," which brought forth comments that would indicate they had received serious attention, a condition that did not prevail in the case of news articles. Local ordinances have been passed in some states making mosquito breeding a misdemeanor. A state law to that effect would be far-reaching and prove very valuable if enforced.

In 1922 and 1923 the physicians of a city in Georgia took an active interest in the educational phase of the work as part of an extermination campaign, with good results. Boy Scouts were used to excellent advantage in house to house inspection in and about the city of Chicago, this year, as previously mentioned.

In a community where no inspection force is employed for the purpose of locating mosquito breeding places, the police could report the accumulation of water in the open places and the services of both Boy and Girl Scout units could be enlisted to inspect the water, both in the open areas and on private property, reporting the breeding places found to the local Board of Health. Where the Scouts have been used for that work great interest has developed in their organization

by their being given an opportunity to take part in public health work and considerable benefit has resulted which otherwise would not have been attained, due to the impossibility of the health forces being expanded to include this work when the need for it became apparent.

The following side lights, being rather interesting, are furnished for your information:

A member of your Committee relates that while a passenger on a fog-bound steamer five miles off the Massachusetts coast, in the latter part of August, he found sollicitans so troublesome as to be almost unbearable.

Proceeding farther north, the McMillan Polar Expedition reported in July, from its station on the east coast of Labrador, that mosquitoes were so annoying as to render sleep almost impossible for several days. It was stated that some of the men sought relief by climbing to the top of the ship's mast, by which action they imitated the custom of the Egyptians in early ages making their homes in towers to escape the onslaught of mosquitoes.

A bit of news which reached the Committee as to malaria conditions abroad is that there were 5,000,000 cases reported in Russia in 1924.

For their courteous assistance the Committee extends its thanks to Col. J. A. Le Prince, Senior Sanitary Engineer of the United States Public Health Service, and the Sanitary Engineers of the several State Boards of Health, who have supplied information as to conditions prevailing in their territory.

RECENT HIGHWAY RESEARCH DEVELOPMENTS

By Charles M. Upham, Director of the Highway Research Board, National Research Council, Washington, D. C.

(Editor's Note: The following address by Mr. Upham was presented at the 1925 meeting of the American Association of State Highway Officials at Detroit, Nov. 18-21.)

In the development of every science there are certain periods which stand out as epochs in the progress of that science. Just as the Bates Road, the Pittsburg (Calif.) and the Arlington tests were distinct developments in the science of highway construction, so the investigations financed by industrial concerns and conducted under the auspices of the Highway Research Board of the National Research Council mark a new era in highway research. There are now several of these studies under way, and in every case they are concerned with a moot problem in highway work which no state highway department or industrial organization would ordinarily conduct alone. The studies undertaken are national in scope, and the Highway Research Board offers auspices under which such work may be carried on that is scientific in character and impartial in its findings. It is gratifying to note that the Board has secured the fullest co-operation from the state highway departments and other organizations engaged in highway research in the prosecution of the studies it now has under way.

Economic Value of Steel Reinforcement

The first such study to be undertaken by the Board was that on the Economic Value of Steel Reinforcement in Concrete Roads. In connection with this work, careful field inspections have been made in every section of the country, and information is now available which covers all conditions of service and is representative of every State in the Union. The final report on this investigation, which will be presented at the Fifth Annual Meeting of the Highway Research Board in December, will be the most complete study of reinforced concrete roads ever undertaken. It is expected that as a result of this investigation the matter of reinforcement in concrete roads will no longer be a moot question.

Earth Roads

Another investigation being conducted under the auspices of the Highway Research Board, and one which will be of utmost importance to the public for many years to come, is that on the Development of Earth Roads. Although the title of this investigation appears to limit its scope, the object is to determine some type of road surface that will be low in first cost and maintenance and suitable for light traffic. Thus far, only the preliminary stages of this investigation have been made, but these show what has been done and what is now under way in attempts to solve this problem. Field inspections will soon be undertaken which will indicate further research needed in order that methods may be evolved which will, at comparatively small expense, put our secondary roads in proper condition to serve as feeders to our main highways.

Culvert Pipe

Much interest has been shown by engineers in the Culvert Pipe Investigation. By means of correlation of existing studies and by field inspections, it is hoped to determine the proper basis of comparison for evaluating the life, usefulness and economic value of different types of culverts and small drainage structures in use. Engineers will then have scientific data on which to base their decisions, thus replacing the uncertainty which now exists in the design of this important part of the highway.

State Highway Financing

The state highway departments have responded splendidly to the study of the Urban Highway Finance problem also being conducted under the auspices of the Highway Research Board. This investigation is of great interest and importance to the general public as well as to engineers, as it treats of the relation of the city dweller to rural highway finance and of the financial aspects of widening of city streets and of city traffic control. In addition to the studies enumerated, the Board has been requested to undertake similar researches looking toward the solution of certain problems in highway engineering.

The activities of the Highway Research Board have not been confined solely to the solution of technical problems. In addition, considerable work has been done in acquainting the public at large with the economic value of highway research and the desirability and need for giving support to this type of work—both from the local, as well asthe national standpoint. This has been carried on through radio addresses and by newspaper and technical articles. Plans are under way for developing this work to an even greater extent, as it is felt that the promotion of highway research can only continue as it has public support which is based upon a knowledge of the sound economic value of this work.

College Relations

In addition to its contact men from the state highway departments, the Highway Research Board recently enlarged its sphere of activities by securing representatives from the universities and colleges throughout the United States. This makes possible not only a closer cooperation between the Board and the universities conducting highway research, but also serves as a means of bringing to educational authorities and to engineering students information concerning the work being carried on throughout the country on highway research. Since these representatives have been named, there has been much evidence of a desire on the part of the universities to assist in the development of the highway research program and many requests have been received for information and guidance as to how they may cooperate in this important work.

Another significant development has been the extension of contacts with the Latin American countries which are now developing programs of highway construction. The Highway Research Board has felt that by giving to these organizations the benefits of accumulated highway research not only would this be of advantage to the cause of research in the United States, but it would serve to develop more fully our international relationships.

Highway Research News

A recent development, which has been receiving a splendid reception from highway research workers, is the issuance by the Board of a Bulletin twice a month known as Highway Research News. The object of this publication has been to weld together highway research personnel throughout the country; acquaint research workers with what is going on in their particular field of work; encourage them to avail themselves of the services of the Highway Research Board in connection with their studies; and incidentally to acquaint the public at large of the economic value and significance of highway research.

A policy which the Highway Research Board hopes to put into full effect during the coming year is the employment of technical assistants to give full time to the work of research committees. It is well realized that committee members are very busy men and cannot devote the time necessary for the detail committee work.

Summary Bulletin

A very enthusiastic reception has been accorded the Summary Bulletin which which was issued by the Highway Research Board, giving in concise form the principal facts of highway research which may be practically applied as presented at the last two annual meetings of the Board. It has been found necessary to reprint the first issue of this Bulletin, a total of 8,000 copies having been distributed. This would indicate that the Summary Bulletin is an outstanding contribution in the presentation of the finding of high-

way research to all persons engaged in this field.

During the past year, considerable increase has been noted in the number of requests for information received by the Board concerning many matters of Highway Research, thus indicating that the information service conducted as a part of the work of the Board is really establishing this organization as a national clearing house for all matters pertaining to highway work.

Another important development during the past year has been the summarization of highway research progress that is being made by the United States Bureau of Public Roads and which is appearing in Public Roads, the research journal issued by that organization. These studies bring together the results of highway research in particular fields, thus giving the highway research worker a perspective of what has been done in that field and serving as an incentive for the continuation of further studies. Mention should also be made of the research done by the Bureau in connection with highway construction operations, a subject of vital importance, and one which has long been neglected. These studies have revealed the reasons why production in highway building so commonly fails to reach levels theoretically possible.

The contacts of the Highway Research Board with the state highway departments show that they recognize that the results of highway research are of national rather than of local importance. The departments have evidenced a desire to avoid duplication of effort and a willingness to place into immediate practice research results from other states that may be adapted to their local conditions. The investigations by the Highway Research Board have brought to light considerable material which would not otherwise have received the wide currency that will be given to it as a result of being included in one of these national studies.

The excellent spirit of cooperation shown by the state highway departments is evidence that the Highway Research Board of the National Research Council is meeting a need among the states for a national agency to coordinate highway research throughout the country and to serve as a clearing-house for all highway research matters.

PRESIDENT OF A. A. E. ADDRESSES FRANK LETTER TO MEMBERS

(Editor's Note: The following frank letter was addressed to the members of the American Association of Engineers, under date of Dec. 9, 1925, by D. B. Steinman, President of the Association. Members of Associations frequently need such letters but so far as we know this is the first time they ever got one. After watching the antics of the A. A. E. in recent years we are of the opinion that the affairs of the organization are greatly in need of, and can scarcely be injured by, the very frankest sort of discussion. The full text of the letter follows:)

This is a plea for a corrected perspective and sense of proportion.

There are members in our organization who are acting like a lot of kids in a high-school literary society, expending their time, energy and enthusiasm on fighting over by-laws and amendments.

The same energy and enthusiasm devoted to furthering the fundamental aims and purposes of our Association would accelerate accomplishment and would make A. A. E. the outstanding success in the history of professional organizations.

The elected leaders of the Association cannot do their best work in conceiving inspiring and directing worth-while activities when their energy is sapped and their time is consumed in the necessity of fighting misguided attacks from within the organization.

A review of the past history of our Association shows an undue proportion of distraction and controversy over questions of dues, by-laws and amendments. The annual conventions, with their dreaded periodic agitations of constitutional changes, have left their scars in the form of weakened unity within the organization and weakened standing in the profession.

The National Officers and Directors, who are elected representatives of the membership and who are therefore responsible for the success of the Association, realizing that the conditions above described have been impeding the growth and retarding the success of the organization, have courageously effectuated such changes in the by-laws as they conscientiously felt were necessary for the smoothest most efficient, and most successful operation of the Association in the future.

The major changes made, those relating to separation of dues, were approved

in advance by an overwhelming vote of the membership.

Other relatively minor changes were made at the same time, so as to clean up this matter of constitutional changes, instead of leaving it like a Sword of Damocles hanging over the Association. With the definite settlement of the petty controversial questions in such manner as will lead to the simplest and smoothest operation of the organization in the future, the decks have been cleared for action. The energies of the Association have been released for more important things than perennial controversies over dues, by-laws and amendments.

With a distorted sense of proportion, with a twisted perspective that is focused only on by-law controversies, some misguided members are violently protesting, and their hasty and one-sided protests are taking the form of ill-advised attacks that can only tend to weaken or wreck the organization.

The elected national officers and directors are held responsible for the success of the organization. There should be no responsibility without authority and confidence. Surely, engineers of all men, should recognize this principle.

The protests declare that the national officers and directors have amended the by-laws so as to increase their own authority and powers. This is a misrepresentation or a misconception. Granting, however, for the sake of argument, that the officers have increased their powers, is that sufficient ground for agitation that endangers the life of the organization?

The important consideration is not the amount of power the officers have, but the way in which that power is used.

When you find that any officer abuses his power for selfish interests at the expense of the Association, that is the time to raise a howl of protest.

When you find that any officer attempts to pervert the purposes of the Association, that is the time to awaken your fellow-members to action.

When you find that any officer is guilty of dishonesty or graft, disloyalty or selfish misrepresentation, that is the time to fight for his removal.

But as long as your elected national officers are sincere, honest and conscientious in their devotion to the interests of A. A. E., they are entitled to your confidence, loyalty and support. Until you find your elected officers selfishly abusing their power, their sacrifices and sincere devotion entitle them to every fair consideration, certainly to freedom from unfounded suspicion, from misguided abuse, and from underground attack.

Give your elected officers all the authority and power they are willing to take, and then hold them responsible for the honest and conscientious use of that power toward advancing the purposes of the organization. In judging the use or abuse of that authority, do not allow your focus to be distorted by petty questions of by-laws; the important test is the sincerity of purpose, the energy of accomplishment.

We have concentrated our attention too long on trivial and stupid controversies over by-law amendments. As an organization of professional men, we have more important problems demanding our best thoughts and energies. Let us forget the childish disputes over amendments and press on, with a united front, toward worth-while achievement of our true purposes.

ECONOMIC ASPECTS OF SNOW REMOVAL FROM HIGHWAYS

A four month's investigation covering snow removal has just been completed by the Caterpillar Tractor Company and the results of the survey incorporated in "The Snow Removal Book".

The book covers practically every important phase of the question, including work now being accomplished, organizations interested, cost of snow removal, methods of financing, activities of civic organizations, snow removal and the highway transportation industry, snow removal and the automobile, special problems in western states, drift control, methods and organization in cities, snow removal equipment and many other related subjects.

The book points out that in the Snow Belt of the United States, it is estimated that there are now (1925) more than 134,000 miles of public highways, surfaced with gravel or higher types of pavement at an estimated cost of $3,350,000,000, and used by 90,000,000 people. Following are extracts taken from the pages of "The Snow Removal Book":

The protection of this enormous public investment is but one of the many sound reasons for maintaining year-around travel. The saving in interest charges alone

may more than justify the expense of snow removal.

In states collecting a gasoline tax, the increased revenue from motor vehicles that otherwise would be idle during the winter months, may exceed the entire cost of winter maintenance.

This includes—in addition to damaged road-surfaces and losses on highway investment—the interest charges on millions of idle motor vehicles; winter depression in the oil, automobile-supply and related industries; increased costs and decreased revenue in nearly all lines of business added fire hazards; interference with travel; and untold inconvenience to the public in all walks of life.

Merchants in cities and towns are the heaviest losers in this unequal game of chance. The estimated cost to New York retailers of a twelve-day tie-up resulting from a blizzard, was $60,000,000. A single storm in Chicago decreased the revenue of down-town stores to the extent of $20,000,000! These figures were arrived at by taking the average trade during the corresponding period for several years.

During the winter of 1924-1925, nine states included their entire state system of highways in the snow removal program: Rhode Island, Connecticut, New Jersey, Pennsylvania, Delaware, Maryland, Illinois, Iowa and Nebraska. Twenty seven other states carried out programs varying from a policy of snow removal only in the immediate vicinity of large population centers, to the clearing of principal through-routes.

Definite snow-removal programs affecting more than 48,000 miles of road were reported by the State Highway Departments of the 35 states that lie in the area where snow precipitation averaged 20 ins. or more during the winter of 1924-1925, representing an increase in mileage of 36 per cent in two years!

In the 36 states entirely or partially affected by snow blockades are concentrated nearly 75 per cent of the population; approximately 63 per cent of the motor vehicles; and more than 53 per cent of the improved roads of the Nation.

The National Automobile Chamber of Commerce estimated that early in 1925, in the 35 states of heavy snow fall, there were 4,479 bus companies operating 16,210 buses, covering routes which served 112,509 miles of highway.

That the cost of snow removal has been greatly exaggerated in the minds of many persons is the contention of V. R. Burton, Engineer of the Michigan State Highway Department. In an address at the annual conference on highway engineering, University of Michigan, February, 1925, he stated:

"Kent County, Michigan, where the snow problem is very difficult, kept its roads open during the year 1924-1925 for less than $25 a mile. Snow removal is practically the only maintenance cost during the winter and does not exceed $100 per mile in any Michigan county, with an average of about $30 for southern counties. This compares to summer costs of about $75 to $150."

The difficulty of estimating costs, however, is emphasized by many officials, J. A. Duchastel, City Manager of Outremont, Quebec, says, "Probably no item of expense is so uncertain and therefore so difficult to provide for in the budget."

Less accurate cost data are available from cities than from county and state officials, owing to the fact that snow removal is included with other street maintenance work. However, records compiled by City Engineer S. S. Bunker, of Bangor, Maine, and published by the Bangor Chamber of Commerce, indicate that snow has been removed in that city with a 10-ton tractor at a cost of $9.52 per mile, not including insurance, depreciation or garage rental. The average cost on six main highways radiating from Bangor was $20.93, according to the Chamber of Commerce of that city.

The methods and type of equipment used, of course have an important bearing on costs. It is the opinion of B. E. Gray, Division Engineer, State Road Commission of West Virginia that in so far as possible the same equipment used for grading and summer maintenance should be employed for snow removal.

Probably one of the principal factors leading to the purchase by public officials of thousands of Caterpillar tractors, is the versatility of this machine, equally adaptable for road work, hauling, grading and snow plowing, which reduces operating costs to the minimum.

American Automobile Association statistics, show that up to September 1925, the number of automobiles had increased to approximately 18,000,000, of which 63 per cent or 11,340,000 were in the Snow Belt states. Adding to these the 750,000 cars (in round numbers) registered in Canada, we have a grand total of 12,090,000 motor vehicles which at an average valuation of only $1,000 each, are worth the staggering aggregate sum of $12,090,000,000.

Interest on this sum at six per cent amounts to nearly $2,000,000 a day. No further comment is necessary to show why the owners of these cars are interested in avoiding unnecessary snow blockades!

Although the science of snow removal had developed within the past few years, amazing progress has been made in the development of powerful mechanical equipment.

The Michigan State Highway Department says that probably no other class of highway construction and maintenance equipment is being developed as rapidly as the snow-plow owing to the careful study of its operation by highway officials and manufacturers.

Power, speed and strength of construction are the three principal essentials of efficient snow removal equipment, according to the U. S. Bureau of Public Roads. The Caterpillar tractor is the Backbone of most snow removal work, because of both its track-laying feature and its great power and sturdiness. From city sidewalks to mountain passes various sizes of Caterpillars are used in great numbers by practically all communities of the Snow Belt.

Engineers are practically unanimous in the opinion that heavy-duty tractor equipment is necessary for heavy snowfall and deep drifts.

Snow plows are of three general classes: (a) adjustable, straight-wheel blade type with curved surface for attachment to the front of tractors; (b) "V" tpye, for similar attachment; (c) rotary type. A variation of the "V" type is equipped with adjustable side-wings, designed not only to penetrate the snow but also to lift it clear of the road. The "V" plow of larger size is usually powered with a tractor.

The rotary type is a newer development which has met with special favor in the West. Its higher first cost, however, has tended to prevent its more general adoption. Still the rotary is regarded as the ultimate type by many engineers. It is especially efficient in very deep drifts and has the added advantage of scattering the removed snow 30 to 40 ft. from the center of the road.

The vitally important thing in snow removal is constant, even dependable power of the operation of snow plows and other equipment. Experience has proved that Caterpillarf tractors supply this power, particularly on difficult snow removal jobs.

Snow removal methods are divided roughly, into three classifications:

Those employed on western and mountain roads; on eastern middle-western and Canadian highways; and in cities.

There are certain rules, however, on which practically all authorities are agreed. These may be summarized as follows:

(1) There must be some central, responsible authority, to whom the entire organization will look for instructions and leadership, such as: (a) maintenance divisiion of the State Highway Department; (b) county road official; (c) city street department.

(2) The organization must be capable, physically efficient, well-trained, self-reliant and imbued with the determined spirit of battle. Each individual should have a definite assignment.

(3) The territory must be intelligently divided and each division must have its quota of men. There should be a "lieutenant" in charge of each division.

(4) Men and machinery must be ready to begin work on short notice, and to work at top speed, night and day in emergencies. Therefore, the organization should possess reserve forces sufficient for relief when necessary.

(5) Mechanical equipment, tractors, snow plows etc., should be kept in warm storage to facilitate quick starting and be overhauled in advance so as to be ready for immediate use. Spare parts should be conveniently at hand.

(6) A definite program for all phases of the work should be laid out in advance, preferably in summer and fall, and each division commander should be familiar with all details.

(7) The organization must possess an intelligence department which must at all times keep each division in touch with the other and with headquarters, and which must keep informed as to weather conditions. This department may make use of telephone, telegraph, radio and mails, receiving the co-operation of the U. S. Weather Bureau, which is rendered free of charge.

(8) Work should be commenced as soon as the snow begins to fall and continue without interruption until the roads or streets are cleared. The general practice in road work is to begin plowing before the precipitation has exceeded 3 ins. An exception is where extremely heavy snowfall occurs in a short time.

(9) As great a width of highway as possible should be cleared, because: (a)

there is less likelihood of damage to the roadway through freezing and heaving; (b) the work of plowing is rendered less difficult later in the season if the early snow-fall is pushed well back. Also less packing occurs from traffic. Some officials prefer to clear the center of the roadway during the storm and then push the snow back further after the fall has ceased.

(10) The surface of the road should be left clean except in cases where it is necessary to provide for sleighing.

(11) Ditches and drains must be kept open. As soon as the road is cleared, shovelers should be set to work immediately clearing culverts and cutting openings to side ditches.

(12) Arrangements must be made for paying promptly, in cash, any extra labor employed.

The battle against snow is on in earnest. The public no longer accepts the burden of snow as inevitable. With powerful tractors as power units for sturdy snow plows and a will to keep the roads open in winter, the weapon is at hand to establish effectively the new era of free winter travel.

HEAVY SUBGRADE SOILS NOT IMPROVED BY ADULTERATION

Importance of good subgrade to highway paving led to the inauguration by California highway commission several years ago of a series of experiments to determine the merits of several proposed methods of treatment of adobe soils which, by reason of instability under varying conditions, have presented a most difficult problem to road builders in this state. Results of these experiments have just been analyzed by C. L. McKesson, research engineer of the highway commission, who finds that adulteration of the subgrades with cement or lime compounds as a means of improving sub-base conditions by securing stability in heavy soils is ineffective and uneconomical. A full report of the studies of these experiments is set forth in a report made by Mr. McKesson to State Highway Engineer Robert M. Morton.

Experimental sections were built on the Rio Vista lateral of the state highway system in Solano county in 1921 and 1922. The special subgrade treatment was undertaken in an effort to determine, if possible, an economical method of treating adobe to eliminate its swelling and plastic condition when saturated with moisture, and subsequent shrinkage and cracking when dried out. The plan tried called for the thorough mixing with the subgrade in varying quantities and depths of portland cement, hydrated lime, limestone dust, and asphaltic oil.

The work was started in 1921, and the pavement was completed during the summer of 1922. Twelve sections, with one exception, each 500 feet long, were chosen, an effort being made to select those with soil conditions as nearly identical as possible. An examination shows the soil to be adobe and silty clay, with some variations in quality.

The treatment consisted of loosening and pulverizing the subgrade to a depth of six and twelve inches, after which the various adulterants were mixed with the soil and well worked into the sub-base. Except on the experimental sections, a four-inch gravel sub-base was placed on all heavy soil on the paving project. It is possible, therefore, to compare this more or less standard method of subgrade treatment with the various experimental admixtures. An 18-foot concrete slab, five inches in thickness, was placed.

After the work had been down for more than two years, Mr. McKesson made a condition survey. He reports the relative efficiency of the various methods of treatment, based on the present condition of the pavement, as follows:

Four-inch gravel sub-base on untreated sub-soil is found to be very efficient. All sections in good condition. No longitudinal cracks and transverse cracks are 40 to 100 feet apart.

Six-inch sub-base treated with portland cement—Where subsoil is similar, there is little or no difference apparent between sections having 1-10 and 1-20 admixtures. Failures consist of transverse cracks averaging about 40 feet apart.

Twelve-inch sub-base treated with asphaltic oil (5 gal. per sq. yd.)—This section has transverse cracks averaging about 25 feet apart. There is little difference in condition between this section and the 12-inch portland cement sections.

Twelve-inch sub-base treated with hydrated lime—This section has transverse cracks 10 to 60 feet apart, and several short irregular longitudinal cracks. Some surface checking was also noted.

Twelve-inch sub-base treated with portland cement—Sections 1 and c, with 1-10 admixture, are in slightly better condition than sections 2 and d, having 1-20 admix-

ture. Transverse cracks on average about 30 feet apart on sections 1 and c and about 25 feet on section 2 and d. Sections 1 and 2 have a number of longitudinal cracks. The average condition of these sections is slightly better than the plain untreated Section 7, but not enough to justify any expenditure.

Plain 12-inch sub-base—This section was plowed up and soil pulverized as for admixture treatments. It was then rerolled, without the addition of any adulterant. Pavement on this section is in little worse condition than on 12-inch 1-20 cement section, but the soil is apparently heavier than on any other section of the experimental work. A comparison of this section with gravel sub-base sections, shows clearly the benefit to be obtained from the use of a gravel sub-base.

Twelve-inch sub-base treated with limestone dust—This section is in the worst condition of all. The pavement is broken up into narrow strips by the many transverse cracks, and in some places short longitudinal cracks are numerous. Had it not been for transverse reinforcement, this section would probably be a total failure.

Commenting upon the Rio Vista lateral experiments, Mr. McKesson states they appear to justify three conclusions, as follows:

1. That soil adulteration with cement or lime compounds is not an efficient or economical method of securing stability in heavy soils.

2. That the suitability of soil for subgrade purposes, or of the merits of various methods of soil treatments, can be determined by relatively simple laboratory tests and that expensive field tests, in some cases at least, can be avoided by first resorting to a properly conducted laboratory investigation.

3. That a sand or gravel layer is an efficient and economical method of minimizing damage to pavement, resulting from swelling or shrinkage of the subsoil.

In making his report, the research engineer calls attention to the fact that the results of the California tests are similar to those obtained by A. C. Rose, who conduced like experiments for the United States bureau of public roads at about the same time. The federal experiments were made with Cove clay, a soil similar to the adobe of the Rio Vista lateral, in this state.

In the report of his tests Mr. Rose says:

"Adulterating the subgrade with a lime compound or sand to a depth of one foot reduces shrinkage in the portion adulterated, but the sub-soil for a considerable depth beneath this treated layer would continue to swell and shrink and displacement of the upper layer and of the pavement would doubtless continue, although to a less degree. The efficiency of this method of sub-grade treatment is doubted.

"It is believed that a better treatment of heavy soil subgrade is:

"1. To use a sand cushion to act as an equilibrant to run into irregularities of the subgrade, which is deformed by shrinkage or swell of the soil, and thus to maintain uniform surface in contact with the base of the pavement, or

"2. To establish an unchanging moisture content in the immediate subgrade."

THE IMPROVEMENTS OF GRADE CROSSINGS

From the Michigan Manufacturer and Financial Record.

The announcement by the governor of Michigan that the next policy of the administration will be to expend a large sum of money on grade separations—the figure is put at $20,000,000—will send cold shivers up the backs of those who instinctively shrink from new forms of public expenditure. Yet it is wholly of a piece with the logic that provides good roads at all that the good roads should be made safe for human life and travel. The provision of improved roads has been followed by their use. The opening up of every thousand miles of modern roads seems to be followed, as an immediate consequence, by the addition of approximately 20,000 new motor cars to be added to the number already using the roads in existence. The use of the motor car has increased the speed of travel from the four or five mile an hour gait which characterized horse travel to an average of something over 20 miles an hour by mechanical motive power. Even this latter figure will not be accepted as an average by those who think of the automobile in terms of 30, 40 and 50 miles an hour, but the average is still as low as the figure we have named. Its existence as an experience indicates that the average driver is not a speed fiend, and that the new kinds of roads, for they are still quite new, are not being made speeding tracks, and that the dangers incident to accelerated travel are not the results of dare-devil use. A natural and logical increase of public danger has, therefore, resulted from the de-

velopment of better roads. Added to this condition is the growth of population and the increased demand for movement consequent upon increased facility. In addition to these are the accelerated movements, both in speed and number of trains on the railroad rights of way.

These conditions combine to make necessary a more general provision for safety in crossings than has been required in the past. With a wise provision of necessities in this direction Gov. Alfred E. Smith, of New York, more than a year ago sounded a note of preparation for an almost wholesale revision of crossing conditions in the Empire State, so that the people of that state have authorized a form of debt-making for this purpose which will even go so far as to advance to the railroads, a share of their cost in the operation, this share to be repaid over a long period of time.

So that it will be seen that Gov. Groesbeck, in announcing a policy of grade separation, is advancing nothing new, except that his policy is for Michigan. The expenditure, if wisely made, will bring an adequate return upon itself, in actual money values of the saving of human lives and the saving of time devoted to road travel. The cost of a $20,000,000 grade separation program, amortization and all, would not be much over $1,000,000 a year, and it doesn't require a very observant eye or a statistical mind to find that much value alone in the motor cars which are the subject matter of crossing accidents in a year's time, let alone the harm to life and limb. The new policy may be administered so as to become a burden to the railroads—by which is meant the users of the railroads who provide their incomes—and it may be administered so as not to become such a burden. It is sincerely to be hoped that the latter policy will prevail. But in their present prosperity, the railroads may be looked to to do their share. In the long run they will profit by improved conditions, too.

EFFICIENCY IN CONCRETE ROAD CONSTRUCTION

By J. L. Harrison, Highway Engineer, U. S. Bureau of Public Roads, Washington, D. C.

(Editor's Note: The following article is reproduced from the November, 1925, number of "Public Roads", issued by the U. S. Bureau of Public Roads. The article discusses observations made on going projects by the Division of Control, Bureau of Public Roads.)

For many years the construction of concrete pavements has been an important element in the volume of highway work offered contractors. It has also been a large and a growing item in the improvement of city streets and alleys. Probably no figures which purport to give the volume of this work are absolutely accurate, for the very multiplicity of the sources from which such figures must be collected renders absolute accuracy difficult of attainment. However, there is no reason to doubt that recent statistics which show that concrete pavements are now being produced at the rate of about 92,000,000 sq. yds. a year and at a gross annual cost in the neighborhood of $250,000,000, fix the order of importance of this element in the paving contractor's work with sufficient accuracy to justify the statement that it constitutes an extremely large item in the highway construction field.

There can be no doubt that any construction field in which this enormous sum is spent annually ought to be the subject of constant study. This is true without regard to what the field may be, for research and investigations are likely to prove quite as profitable here as they have in such fields as the physical sciences, and in such industries as the manufacture of automobiles. Highways of all sorts are now all but exclusively financed by, and constructed under the direction of governmental agencies with the result that in this field there is a direct relation between efficiency and the tax burden which makes it particularly important that constant effort be made through research and investigation to develop efficiency.

Efficiency is a broad term. Full efficiency in the highway field would begin at least as early as the selection of the routes to be improved. It suggests the development of the principles governing location. It dictates that the designing engineer shall consider the effect of his plans and his requirements on the cost of construction as well as on the probable adequacy of the finished structure. It is as insistent on the proper performance of all necessary operations as it is on the elimination of all that are unnecessary. It urges the contractor toward greater thought in planning and arranging his work and finally it imposes on those in charge of maintenance the requirement that whatever is built shall be so cared

for as to yield the greatest service to the community.

Efficiency in the construction of highways is, then, only a part of the greater field of efficiency in highway development and maintenance, and efficiency in the construction of concrete surfaces is but a part of the whole highway construction field. Still, the savings which would result from full efficiency in this field are so large that they justify the annual expenditure of considerable sums of money in research and investigation if thereby approach can be had to complete efficiency. The current difference between ordinary practice and full efficiency will be appreciated when it is known that the studies made by the Bureau of Public Roads indicate that there are very few projects on which the average daily output can not be increased 25 per cent, that on many it can be increased from 50 to 100 per cent, and that as this can be accompanied by some reduction in the amount both of labor, and equipment, the labor expended per mile of pavement laid, can, in general, be reduced by perhaps 50 per cent, and charges for depreciation of equipment by an even greater amount.

A Series of Articles

The series of articles, of which this is the first, is based on extended field studies of going projects by the division of control of the Bureau of Public Roads. In these studies it has been the purpose to determine what efficiency contractors at present secure, what causes prevent the securing of full efficiency, the degree to which these causes interfere with full efficiency, and how they can be remedied. Finally, having determined these facts in what has appeared to be a satisfactory manner, the effect on production of eliminating the ascertained causes of low efficiency has been tried on a number of projects with results that have quite satisfactorily confirmed the accuracy of the studies.

Full Production 48 Batches An Hour

What is full efficiency? In this series of articles it will be assumed that it is measurably secured when a 100 per cent output is obtained from a properly-equipped job with a crew of proper size. There are, then, a number of distinct fields in which efficiency must be attained before full efficiency is secured. To clarify this statement a little, it may be suggested that when a 100 per cent output is obtained with a 150 per cent working force the work is obviously not performed with full efficiency. Similarly, to obtain a perfect output with a working force of correct size but with a plant which represents an investment 50 per cent in excess of reasonable requirements is not to attain full efficiency. Any discussion of efficiency must deal then, if it is to be complete, not only with production but with labor requirements and with equipment as well. But, because production is at once the point of easiest approach to the general problem in hand, and the point at which current practices most clearly show their failure to reach full efficiency this phase of the general problem was the first studied and will be the first discussed.

At this point it may be well to raise the question, what is full production on a crete paving job? The answer will be given categorically: 48 batches an hour—1 batch every 75 seconds. By whatever amount a contractor fails to meet this standard he is failing to reach full efficiency in production, assuming of course, that the specifications require a 1-minute mix. If a 1¼-minute mix is required, one batch should be obtained every 90 seconds, and if a 1½-minute mix is required, one batch should be obtained every 105 seconds. The 1¼-minute mix, then, reduces output to 40 batches an hour, and the 1½-minute mix to slightly over 34 batches an hour. As, for reasons that will later appear, these reductions in output are not accompanied by equivalent reductions either in daily pay roll or in plant investment, any state, county, or municipality using one of these longer mixing periods, should have very conclusive data at its disposal if it is to justify the additional unit cost of pavement laid, which it must expect to pay.

One-Minute Mix

Because of this fact, and because the current tendency, which is governed by recent tests, seems to be to standardize on a 1-minute mix, the discussions which follow will be based on a mixing period of that length. It should not be forgotten, however, by those interested in obtaining the highest standards consistent with reasonable cost, that current practice in testing concrete to determine the proper time of mix, the proper consistency, etc., is much at fault in that it examines the material discharged from the mixer, or as deposited on the subgrade, rather than the material in place and finished. Between the discharge from any really modern mixer and the final belting, the mixed material, is poured into a large bucket dumped upon the subgrade, shoveled,

tramped over, etc., by the puddlers, and smoothed or tamped by a modern finishing machine. The subgrade absorbs some of the water content and some evaporates. All of these operations tend to work the concrete more completely, and particularly to distribute and correct the water film with the result that the material which the belt leaves as a completed slab often is by no means the same material which was discharged from the mixer perhaps a half hour before.

Operations Involved in Production of a Batch

Returning now to the production standard defined above—48 batches an hour—and with the fact in mind that this standard is based on a 1-minute mix, the correctness of this standard may reasonably be examined. The operations which must be performed in turning out a batch of concrete are as follows:

1. The skip must be loaded. This can be done while the previous charge is being mixed. Under the somewhat antiquated system which requires that the cement be brought to the job in sacks and there piled along the road, the operation of dumping the cement into the skip will sometimes take longer than mixing the batch. Of course this method of handling cement is as obsolete as are all other purely manual methods, but if it chances to be the method in vogue, men who are strong enough and active enough to do this work within the time available should be put onto this work. Ordinarily, however, handling the cement does not prevent charging the skip within the time available for this purpose, generally from 40 to 50 seconds.

2. The skip must be raised to a vertical position for the purpose of dumping the batch into the drum. On a modern mixer in reasonably good condition this operation takes from 9 to 10 seconds, during which period the material in the skip is discharging into the mixer only during the last 1½ to 2 seconds.

3. The material in the skip is never fully discharged when the skip reaches the vertical position and sets the timer. The better modern mixers sometimes discharge the skip in as little as 3 seconds after it is in vertical position, if the sand and coarse aggregate are dry; but under ordinary working conditions they tend to require from 4 to 5 seconds, running a little over 5 seconds if the aggregate is wet enough to moisten the cement appreciably. A recently developed 6-bag mixer quite generally shows a lag in the skip discharge which runs over 15 seconds—one-fourth minute—and an old-fashioned 8-bag mixer, of which a few are still in use, has been found sometimes to take as much as 40 seconds to transfer all of the charge from the hopper into the drum. As there are a number of standard (5-bag) pavers which will discharge the skip in from a little under 4 to a little over 5 seconds and which, under ordinary working conditions, will regularly discharge within 5 seconds after the skip reaches a vertical position, this period is considered standard for the lag in charging as mixers are now designed.

4. The mix must be retained in the drum the full specification period, here assumed to be 60 seconds.

5. Every mixer should have on it some device for timing. A timer which rings a bell at the completion of the mixing period is the one most commonly encountered. When the bell rings the operation must move the discharge lever and the discharge mechanism must open the discharge before material appears in the discharge chute. These operations generate a lag, partly due to the fact that no human being reacts instantly to any ordinary stimulus and partly to the fact that it takes time for the mechanism to work. Two seconds seems to be about the bottom limit for this lag, which is termed the discharge lag. Three seconds is a more common average; and sometimes it runs as high as four seconds. The lag in discharge tends to offset the lag in charging, but can not reasonably be so treated if it is not a uniform lag. Thus a lag which for successive batches is found to be 2.7 seconds, 3.2 seconds, 2.8 seconds, 3 seconds, 3.1 seconds, 3.3 seconds, etc., over long periods might reasonably be treated as a 3-second lag, though the amount by which this lag exceeds 2 seconds is due entirely to a slow reaction on the part of the operator; but a lag reading 1.9 seconds, 3 seconds, 2 seconds, 4.2 seconds, 2 seconds, 2.2 seconds, 5 seconds, 2.1 seconds, 4 seconds, 3.1 seconds, etc., would appropriately be treated as a 2-second lag because the part chargeable to the operator is not uniform.

6. Finally the mix must be discharged. A wet mix can be quite thoroughly discharged from a good mixer in as little as 8 or 9 seconds, but there is no mixer now on the market which will make a complete discharge in less than 10 seconds, if the consistency is such that it meets present requirements as to slump. This is, in a general way, caused by inadequacy of bucket capacity. Concrete hav-

ing a slump of about 1 inch flows slowly in the chute and piles up in the bucket with the result that as the bucket fills the discharging concrete finally backs up into the chute, preventing complete discharge within any reasonable period. To complicate matters further, all mixers dribble a good deal. A recently designed 6-bag mixer will often take well over 20 seconds to complete the discharge. Some of the older mixers take quite as long, a few longer. A full batch mixed to proper consistency can, however, be regularly discharged from most of the standard (5-bag) pavers in 10 seconds if the charge in the drum is "built up" slightly, that is, if a part of the first batch is left in the mixer and the mixer is allowed to run that way. The quantity required is small just enough to force a full rate of discharge during the whole of the discharge period. As, under full efficiency, a new batch is handled every 75 seconds, there is no practical disadvantage in this as the quantity of material appearing in any batch which could possibly have been in the mixer over 15 minutes would be too small to be of any importance whatever. The discharge time, may, therefore, be kept within 10 seconds even when a mix of proper consistency is being produced.

Simultaneous Charging and Discharging Necessary for Full Production

The full-production mixing time with all specification requirements met may then be calculated as follows:

Specification mixing time, seconds	60
Lag in charging, seconds	5
Simultaneous raising of skip and discharging, seconds	10
Totals, seconds	75

Stated in this manner there is, however, no recognition of the lags described above. It is therefore preferable to state the cycle as follows:

1. Specification mixing time, seconds	60
2. Lag in charging, seconds	5
3. Less lag in discharge, seconds	2
4. Net lag as affecting timer, seconds	3
Normal setting of timer, seconds	63
5. Lag in discharge, seconds	2
6. Simultaneous raising of skip and discharging, seconds	10
Total mixing cycle, seconds	75

It will be observed that in order to reduce the mixing cycle to 75 seconds the skip must be started up at the same instant the discharge is opened. As a matter of fact this is the only device available to the operator for regulating the length of the mixing cycle. Most mixers dribble their discharge enough so that even an experienced operator would have trouble in regulating the time of discharge by observation of the discharge itself. The time required for raising the skip, is, however, outstandingly uniform and if an operator is trained to open the discharge and start the skip at the same time, and to close the discharge as the skip reaches a vertical position, he has at once an adequate discharge time, an accurate measurement of the discharge time, and, if the lags in charging and discharging are correctly provided for, the correct mixing cycle.

Two things may be observed here. The first is that where the mixer is so designed that 10 seconds is not an adequate period for discharge this system is not applicable. There are such mixers, but they can not be reasonably considered in setting a standard of production. Such mixers may require an extra 5, 10, or even 20 seconds as their minimum mixing cycle. Mixers are not all alike in their efficiency any more than the operators who use them. But to obtain full production a contractor must have an efficient mixer and the above discussion will, it is hoped, assist him in determining which mixers are efficient.

The second matter to be noted is that if practices here outlined are followed the skip will be in a charging position and the material will be flowing into the drum during from 1½ to 2 seconds of the discharge period. This is of no consequence whatever, as the standard drum speed is about 15 revolutions per minute or 1 revolution every 4 seconds. During this overlapping of the charge and the discharge—never in excess of 2 seconds—the drum makes only half a revolution, so the material is not moved up and over in the drum enough to combine with any of the discharging material or to appear in the discharge chute. If the drum speed is so high that unmixed material is discharged the contractor should reduce the drum speed.

The Mixer is the Bottle Neck of the Job

The mixer is the bottle neck on every concrete paving job. No matter what material supplies are available, what correlated equipment is on the job, what skilled laborers or how many are available, indeed no matter what other conditions prevail, be they ever so favorable, the mixer

sets a rigid limit on production which can not be honestly avoided. This is so axiomatic that it naturally follows that the problem of securing full production becomes a problem of determining the factors which are reducing the output of the mixer, what their order of importance may be, and finally how they may be eliminated.

These factors have been determined in the bureau's studies by making stopwatch readings on selected projects for an hour morning and afternoon each day over such a period as seemed necessary to obtain reasonably accurate data. These records, accumulated over a period of from two weeks to a month, tabulated and averaged, give a fairly complete picture of what the rate of production is and of why it is less than it ought to be.

The summary resulting from a two-weeks study of a going project reveals typical construction conditons. Nearly 17 per cent of the working day in this case was being lost at the mixer. Nearly a fourth of this is chargeable to poor handling of the mixer. The timer on this job was not set to take care of the lag in charging. This is not an uncommon condition. Most contractors indeed and many engineers seem to suppose that the material in the skip is all transferred to the drum while the skip is being raised to a vertical position. That this is not the case can be determined readily by getting well up on the mixer and watching the discharge. As most specifications make it clear that the mixing time is the period between the moment at which the last of a batch enters the drum and the first is discharged, the contractor in this case, was obtaining at least a 3-second advantage over the specification requirements but in spite of this, his operator was losing 3.5 per cent of the working time because of failure to overlap the charge and the discharge which together, as measured from the bell (this includes the lag in discharge), should not exceed 12 seconds.

It may be observed that while, as this job was being operated, the loss of time chargeable to the long mixer cycle amounted only to 3.5 per cent of the working day, its importance would have been somewhat increased had other losses been eliminated. In other words, the length of the mixer cycle was cuttting hourly production from a possible 48 batches an hour to slightly over 45 batches an hour or to about 93 per cent of full production. There is here then, and for that matter, in some of the other losses which will be discussed, a difference between the efficiency of an operation itself and the net effect of any lack of efficiency on the day's output. It is possible to develop a study of efficiency on either basis but the latter has been followed in this case.

Poor operation other than failure properly to overlap the charge and the discharge account for a further loss of time amounting to 8.4 per cent. Under this heading are included such practices as dumping batches before the skip is raised, splitting batches, failure to move the mixer while it is mixing, slow reaction to the bell, etc. With an up-to-date mixer it is never necessary to do any of these things. If they are done the operator either has not been properly taught or is deliberately wasting time, or the power plant is so out of order that an expert repair man should be called onto the job at once. The observations made by the bureau's representatives indicate that the general cause of delays of this sort is improper training of operators. Occasionally one is encountered who is naturally slow or indifferent, but it is more common to find that the operator has seen few jobs except the ones on which he has worked and that he does not appreciate that such practices as those here noted throw away a large amount of valuable time.

On this particular job the combined effect of failure to overlap the charge and the discharge and of such items as dumping at the wrong time, splitting batches, slow reaction to the bell, etc., accounts for almost 12 per cent of the working day. With a pay roll running in the neighborhood of $200 a day and a depreciation account of perhaps half that ,amount neither of these being unusual on concrete paving jobs, the direct loss from these causes amounts to about $35 a day, a sum quite sufficient to justify the statement that a "cheap" mixer operator is apt to be about the most expensive man on the job.

Mixer Trouble Expensive

In this case mechanical trouble with the mixer accounts for delays aggregating about 5 per cent of the working time. As mixers wear out such delays tend to increase. They are small when the mixers are new, but even on new mixers the studies show that there generally is a little mechanical trouble. This appears to be due to the rigorous conditions under which mixers operate and to the fact that so many operators are trained on the job,

rather than to any outstanding deficiency in design. But as the mixer wears out, mechanical troubles increase, and with their increase, the lost time mounts sharply. Five per cent appears to be about the average of losses due to this cause. In some cases they amount to upward of 10 per cent. Under the assumptions noted above, a 5 per cent loss of time amounts to about $15 a day and a loss of 10 per cent to $30 a day. If the mixer work 150 days during the year, losses accruing as a direct result of using equipment that is in poor condition will be seen to range from over $2,000 to $4,500 a year. The first of these is enough to pay for a new mixer in about three years, the second in less than two years. It is not the purpose here to go into the question of replacing old machines with new. Rather, it is the purpose to point out that where old or worn-out machines are in use this very fact will prevent full production. Some phases of the problems arising in connection with repairing and replacing machines will be discussed in another part of this series of articles, but it will be sufficient to remark here that as a matter of general observation, there is not enough attention given to the mechanical condition of the mixer, few contractors appearing to realize the real financial aspect of the constantly recurring small losses of time which develop when a worn-out mixer is being operated.

On the job under discussion, the nondelivery of materials accounted for a loss of over 17.6 per cent of the working time. Part of this—13.6 per cent—is chargeable to inadequate truck supply, the balance to improper handling of the trucks. This is a rather typical situation. As a matter of general observation, contractors are prone to provide adequate facilities for the delivery of material. In the case in hand, the apparent truck shortage was 13.6 per cent—that is, with the truck supply available only 13.6 per cent of the working day, worth on the basis of ordinary pay roll and depreciation charges about $40, was being thrown away because of an inadequate supply of trucks, but the real situation was worse than this. Had the mixer losses been eliminated as well as the losses in time due to other causes, the amount of pavement laid would have been increased only by the 4 per cent chargeable to improper handling of the trucks—that is, to a little over 60 per cent of full production. In short, while lack of proper transportation was only costing this contractor some $40 a day as the job was being operated, the value of this loss would have been about $120 a day had the mixer been capable of normal production. It is hardly necessary to observe that the only appropriate method of eliminating this loss is to supply the necessary trucks. Speeding up the trucks in use is not a proper solution, unless the speed at which they are operated is low, which is an uncommon condition. On the other hand, the correction of low efficiency in the operation of the trucks—an entirely different matter—will often measurably improve the apparent truck supply. The transportation question is one of the most important with which the paving contractor must deal—too important to treat at length at this point. It is therefore reserved for further comment in the next of this series of articles.

Small Water Pipes Cause Serious Loss

On this project the water supply caused a loss of 2 per cent of the average working day. Shifting hose is the most common cause of such losses. Poor water pressure is also a common cause. This may be caused by using too small a pump, by slip in the pump, by too small a pipe line, line losses due to poor pipe connections, or to the use of too much water on other parts of the work. Where long pipe lines are used, contractors often try to improve the supply by putting in a booster pump. This results in high pressures, which open joints, split pipe and burst hose. It is not unusual to find that when the valves on the mixer and hose connections are closed, the pressure at the mixer rises to from 250 to over 400 lbs. Such pressures are destructive and wholly unnecessary. Relief valves should be installed to protect the line and the valves in the mixer, but these are often omitted. Larger pipe should be used. The 2-in. pipe now in common use is a "hang-over" from the days when the 3-bag paver was standard equipment. Instead of putting in a 3-in. line and having an adequate water supply with reasonable pressure and a reasonable wear and tear on the pumps, contractors are holding to the 2-in. lines much to their disadvantage, for water trouble has been found to be of common occurrence and a supply inadequate for the mixer and the various curing operations the general rule.

Where contractors have long lines of the now commonly prevailing small sizes of pipe, some relief from the high pressures incident to pumping any considerable volume of water through these lines

can be had by cutting the line and instead of using booster pumps, running the delivery from the first pump into a sump from which the second pump will draw its supply. A great deal of the trouble with short water supply is directly chargeable to line leakage, and this, in turn, is chargeable in no small degree to high pressure in the line. With pressures commonly exceeding 250 lbs., ordinary connections are opened, and all sorts of trouble resulting in leakage occurs. Even the valves in the mixer are sprung and the leakage which occurs here sooner or later becomes an obstacle to the regulation of the water content of the concrete produced. This is a serious matter, since the strength of concrete is adversely affected by even a comparatively small increase in its water content. Moreover, variations in the water content have an adverse effect on the ease and rapidity with which the pavement is finished and make the production of a very smooth surface difficult.

Where there is any considerable leakage the amount of water improperly reaching the interior of the drum varies with the pressure in the line and with the period between batches. As on all but the best managed jobs, both of these are highly variable; as soon as there is any considerable amount of leakage, real uniformity of consistency becomes quite unattainable. So really serious is this matter that it seems proper to suggest that, as mixers are now operated, this is the outstanding cause of non-uniformity of consistency and one of the most important causes of poor surface finish. There is therefore very good reason for urging contractors both in their own interest and in the interest of the States and municipalities for which their work is done, to install pipe lines of proper size, fitted with proper relief valves in order that thereby an adequate water supply delivered at a reasonable pressure may be insured. There is also reason to suggest that manufacturers install better and stronger valves in their mixers.

Delay due to lag in finishing is not of common occurrence. Finishing machines are reliable mechanisms and commonly give the contractor little trouble. The 4 per cent loss from lag in finishing recorded on this project is unusual. Occasionally a complicated or cumbersome process in finishing is required, and in such cases there sometimes is a failure to keep the finishing up with the mixer. Sometimes too dry a mix is required by the inspector. However, the current tendency is toward simplifying the finishing operations so, except where the inspection is too exacting, there is seldom any difficulty encountered here. Incidentally it may be remarked that the essence of rapid finishing is uniformity in consistency and a consistency of proper slump. Well-mixed concrete of the proper consistency—about 1-in. slump—put down by a modern sliding finisher, may be depended upon to be of such uniform smoothness that one man with a long-handled float can finish any output obtainable from a standard mixer. This, of course, implies that the concrete shall be of uniform consistency as well as that it shall be of proper consistency and that the finishing machine shall be correctly operated. In short, there should be no losses of time due to finishing, and if any are developing there is something wrong which should be easily corrected.

Occasionally an inspector, in his desire to obtain the driest mix possible, will attempt to reduce the slump to ½ in. or less. Whatever the theoretical result of such a practice may be, in increasing the strength of the concrete, the practical result under field conditions is to render the concrete extremely hard to work. With a slump as low as this, the finishing machine cannot keep up with the mixer. Moreover, in at least two cases which have come to the attention of the writer, the finishing operation did not satisfactorily compact the bottom third of the pavement. Under field conditions there would, therefore, seem to be valid reason for maintaining a somewhat wetter mix than laboratory tests would indicate to be the most desirable. There is also to be considered the fact that the subgrade absorbs moisture from the concrete and that some evaporates, as a result of which processes the concrete, as finally left by the finishing machine, particularly in hot, dry weather, often is visibly drier than when it left the mixer. If satisfactory production is to be secured, the finishing operation cannot be unduly slowed down. There is here, then, room for a good deal of practical study, for although it is important that the best possible concrete be produced, it is also desirable that this be done on the basis of carefully collected data rather than on the basis of personal opinion, and that theoretical considerations be not allowed to interfere with production unless it can be clearly shown that the results to be obtained can and do justify this interference.

Delays Due to Lack of Subgrade and Other Causes

As with the finishing, so also with the subgrade; if the crew is not doing its work rapidly enough to keep the subgrade in proper condition and so far in advance of the mixer as to entirely avoid delays from this cause, either the foreman in charge needs instruction, additional men or equipment, or the job needs a new foreman. There should be no excuse whatever for letting the preparation of the subgrade interfere with production at the mixer.

Miscellaneous delays are of small consequence on this job. However, the list of them as affecting production a little here and a little there, not often, but occasionally during a long season, is long. Special work at bridge structures falls in this category. Often specifications require a special treatment of the pavement at such points. This special treatment causes delay, generally only because it does not occur often enough so that the crew becomes familiar with the operations involved. Any new operation takes time because men not familiar with it hesitate to proceed lest a mistake be made. Most men working on a construction job do their tasks automatically. Many, if not most, feel confused if any judgment is required. No new or unusual task, no matter how simple, can be handled automatically, and most such tasks for a time require at least a little judgment even on the part of the common laborers. For that reason, whatever is new or unusual is done slowly and output suffers until the operations involved are so well learned through repeated performance that they become automatic.

"Waiting for reinforcing rods" is a minor delay typical of a whole series which may be classed under the general heading of "delays due to the failure to deliver minor materials." Generally such delays are due to the failure of some foreman to keep track of the stock on the job, but if reinforcing material, parting strip, prepared joints, etc., are required, the lack of such materials at the site of the work is quite as effective in stopping production as the failure to deliver cement or sand or gravel. Laying a concrete pavement really is a manufacturing process. Modern manufacturing methods do not depend for their success on large stocks. They depend, rather, on the maintenance of uniform balanced rates of delivery. This is as true of a concrete paving operation as it is of an automobile plant. Materials are not stocked. They are ordered for delivery as needed and such stocks as are maintained are like the balancing tanks in a water supply—they absorb the delivery when it exceeds the rate of use and they augment the delivery when it falls below the rate of use. In the case of minor materials perhaps this is not as obvious as in the case of the materials of major importance, but the fact is that for all materials the rate of delivery at the mixer must harmonize with the rate of use at the mixer, and any failure to attain such a treatment of the material supply, whether major or minor, is too disastrous to pass unnoticed.

There also is a whole series of minor causes of delay not so easy to cover in a general statement, such as: Broken batch meter; getting the mixer under low electric wires; failure to dump all the batch into the skip; over-wet batches thrown away; water pipes frozen, and forms knocked down by trucks. In a general way, delays of this sort are due to accidents or to accidental conditions, and as their causation cannot be foreseen, they cannot well be avoided. However, they are not a serious factor on most jobs, but are mentioned because they illustrate the innumerable minor matters which interfere with securing full production.

The Damage Done by Inexperienced Inspectors

Finally, no discussion of the causes affecting production would be complete without reference to the inspector. He is a necessary, though, it must be regretfully recorded, not always a favorable factor in the production problem. Generally he is a well-intentioned man who knows but little about the broader technical aspects of the work he is inspecting, very desirous of protecting the interests of those he represents, but not properly equipped to pass on the numerous technical questions that arise on any concrete paving job. He occupies a difficult position, because, after all, the contractor's primary desire is production, whereas the State's primary desire is quality. The two are seldom in real conflict, for the best organized and most productive jobs generally do the best work; but high production requires a quick answer to any problem that arises, and this, in turn, requires a broad knowledge of technical values, or, in the effort to protect the interests of his employer, the inspector will find that he is needlessly injuring the contractor. Without this broad technical background, the inspector is apt to be

further handicapped by the fact that he has little appreciation of the real nature of a going construction operation. Here he sees a few men, there a few more. At other points he knows that others are working. He seldom realizes that what he is observing is a machine, the parts of which are so synchronized that to stop one part in effect causes all of the parts to stop functioning. Yet this is literally true.

The modern concrete paving organization, when well developed, is as perfect a machine as a well-built automobile. The subgrade gang is balanced to produce each day the subgrade that the mixer will use the next. The form-setting gang is balanced against the mixer performance in the same way. At the batcher plant the force is kept in harmony with the mixer's utilization of material. The office keeps materials flowing in as they will be needed. In such a balanced production scheme—and this is the very essence of efficiency in production—the injection of any order that stops production at one point stops the whole machine as effectively as taking off a wheel or pulling out the engine stops an automobile. To stop one gang is to stop the whole job. Worse than that, the time lost directly may be of less importance than the time lost indirectly. The writer watched one afternoon an irresponsible inspector while he tinkered with the water gauge on the mixer for a half hour in a misdirected effort to further reduce the slump of concrete which was already well within the specified requirements. The result was a series of batches so dry that the contractor had to stop the mixer for half an hour in order to finish them. This half hour's delay was important enough in itself, but it was a couple of hours before the contractor was able to get his organization to functioning again with its accustomed smoothness.

Although arbitrary acts on the part of inspectors are serious enough, a larger trouble lies in the constant effort of many inspectors to inject new ideas into work on which they are engaged. Some one desires the subgrade prepared in a new way. The finish, it is thought, might be improved. The concrete might be mixed a little drier. It would be improved if mixed a little longer. There are dozens of such requests. It matters not at all that the work now meets the specifications which are in force. If some one thinks that the product can be improved, the contractor will be urged, even forced, into making the desired change. He is told that the change will cost him nothing—may save him money—and will get better results. The point overlooked is that changing the practices on a going job requires more than an order. Men must be trained to perform the new duties properly, and the job may have to be rebalanced to meet the new methods. Often the contractor does not know how to train the men, as he has never seen the new ideas in use. He, therefore, hesitates because he knows that such changes may involve large intangible losses, clear enough to him, but hard to explain to an inspector.

Of course, the time to decide on what methods and practices are to control on a construction job is when the specifications are drawn. Then, when the job is started, the interpretation which will be placed on new clauses or on any of the older clauses that may be in doubt should be made clear, and the practices that are to be required should be developed as the organization is brought into production Thereafter all connected with the job should appreciate that while the contractor may request permission to use new methods, the inspector, and, for that matter, the State, has no right to modify the requirements made on him, unless infraction of specific provisions or commonly accepted interpretations of the specifications can be shown.

Abuse of Discretionary Clauses in Specifications

The clause, "or to the satisfaction of the engineer," and its various equivalents is often written into specifications for the purpose of giving the engineers broad discretionary powers in the interpretation of clauses governing methods, tolerances, etc., and if a contractor objects to an order or to a request, some clause of this sort is called to his attention. For this reason it seems advisable to remark in this connection that as a general legal principle clauses of this sort give engineers no authority to modify the plain intent of specifications defining methods, tolerances, etc., and that contractors are under no obligation to be governed by orders which make these clauses more than customarily rigorous or which increase the cost of the work. As an illustration, if the specifications clearly state that "the slump shall not exceed 1 in.," a clause of this nature cannot be legally invoked to require a contractor to produce concrete having a slump of not more than half an inch. Similarly, if the specifications pro-

vide that "irregularity in the finished surface shall not exceed ¼ in. when measured under a 10-ft. straight-edge," a clause of this character cannot be lawfully invoked to require a contractor to remove areas that are only ⅛ in. high. If the contractor desires to use other than specified methods, etc., and the specifications are not to be followed, then the discretionary clause gives to the engineer broad authority to require that whatever is done under these new methods shall be done "to the satisfaction of the engineer." But in no event are such clauses blanket authorizations for the engineer to make such requirements as he may please.

If it were possible to bring inspectors generally to a realization of the fact that their sole duty is to see that the contractor works within the specified limits, that they are not present to "improve the quality of the work," or to make experiments at the expense of the contractor, the effect on production would be gratifying to many contractors. In making stopwatch studies on going projects it has seldom been possible to separate the effect of improper inspection from other causes which perhaps also contributed to slow operation. Sometimes the fact that an inspector's order is responsible for a procedure that is causing delay has not developed until a good deal of the record has been taken. A case in point was a job where the records showed slow operation of the mixer. In general, the truck supply was adequate and the work well organized, but the mixer operator would not raise his skip until the discharge had been completed. This of course materially reduced his daily output. After the full record for this job was taken it was learned in a chance conversation with the inspector that he would not permit the contractor to produce over 40 batches an hour. There was no specification warranting such a limit on production. The inspector gave no reason for having imposed it. He merely asserted that he thought that production enough. Conditions of this kind as well as the possibility that there might be some difference of opinion as to what is proper inspection, have prevented any general effort to separate the time lost through poor inspection, but some idea of the importance of this element may be gained by the general statement that poor inspection has caused losses of some consequence on more than half the jobs on which the bureau's representatives have made studies during the current season. It is not, therefore, a factor which can be ignored in a study of the causes influencing underproduction.

In presenting these aspects of the inspection problem, the effect of improper inspection and of improper policies governing inspection have been dealt with at some length. It is, therefore, only fair to remark that it is not the purpose to advocate careless or indifferent inspection. Rather the quality of inspection should be improved. The point is that a legal and a moral prerequisite is correct specification writing. If a State desires its concrete pavements finished to a maximum variation of one-eighth inch in 10 feet this can be done. It is perfectly proper that it require such accuracy of final finish and it is practically possible to obtain it. But it is not legally or morally proper to require such a finish under clauses allowing a one-fourth inch variation. Refinements in methods and the reduction of tolerances increase cost. Inspection should be rigid and good work should be insisted on, but back of this there should be a clear specification setting forth what is desired so that the contractor may have a fair opportunity to estimate accordingly.

Some Important Generalizations

The above covers the more important causes of low production. It would be possible with the data in hand to strike averages and to say that this or that is the most important factor in causing low production and to ascribe to it a percentage relation to the whole series of causes, but little could be gained by so doing, for each job is a separate problem and general averages have little relation to the specific conditions there prevailing. Studies such as those the bureau has conducted in this field do, it is true, warrant some generalizations. Mixer operators are, for instance, quite generally undertrained, with the result that few mixers show a proper mixing cycle. Transportation generally is inadequate. Often it is woefully so. As a matter of observation it is apt to be poorly operated. The water supply also is generally inadequate; while the mixer is usually pretty well supplied, the quantity available for curing is commonly insufficient. This list could be extended but to do so has little value for the contractor whose problem is to improve production on his own job of necessity must realize that generalities and averages are a poor approach to the solution of his specific problems. It is well enough

that he should know that mixers are seldom properly operated and that the truck supply is commonly inadequate, but before he can set about the correction of his own low production, he must have the facts as to specific conditions on his own job. These he should obtain just as they have been obtained for these studies by making stop-watch records over such periods as may be needed in order to clearly show what delays are occurring. With the fact clearly in mind that his job ought to be producing 48 batches every hour, it is as simple a problem to determine what delays reduce the output to 35 batches as it is to measure the top of a desk with a 2-foot rule. For studies of this sort a stop-watch is desirable though they can be made with fair accuracy from the second hand of an ordinary watch. If contractors in this field would equip their time-keepers with stop watches and would require them to take an hour's reading morning and afternoon, setting down the results, the information obtained would be invaluable.

Inspectors and superintendents should also be equipped with stop watches. This really needs no argument in its support. No inspector would be allowed to pass judgment on the dimensions of a bridge if the best rule he had was graduated only in feet. Neither would a superintendent be allowed to build a bridge with such a rule as his guide. Yet hundreds of inspectors and hundreds of superintendents constantly direct work today where seconds are valuable on the best guesses they can make from the second hand of an ordinary watch. It may be interesting to add that in the fastest job the bureau's representatives have studied—the only job so far encountered on which the output was consistently maintained at above 90 per cent of full production—the superintendent had and frequently used a first-class stop watch.

CONTROLLING THE CITY'S FINANCES

By George H. Wood, Controller of Accounts, Pasadena, Calif.

(Editor's Note: The following paper was read by Mr. Wood at the 1925 meeting of the League of California Municipalities.)

The City Budget is the compass by which the financial ship of the City must be steered, and it is the duty of the City Controller or Auditor to keep close check on the financial condition of all departments and to advise the City Manager or governing body so that they may be able to steer a safe course and avoid the rocks of deficiency and reach port at the end of the fiscal year with a surplus sufficient to sail on into the next fiscal year until the taxes bring in another cargo.

The duties of the City Controller or Auditor are prescribed by charter or ordinances of the City, the object being to fix the responsibility for accuracy and efficiency in accounting the City's finances.

The financial policy of the city is determined by the governing body when the budget is adopted. Here the Auditor can be of considerable assistance to the governing body, when considering the budget, by having available in convenient form statistical information which can be used as a guide or basis for determining the amount necessary to operate the various departments of the city. Throughout the year it is advisable to maintain a file into which can be placed memoranda from time to time to be taken into consideration when the budget is prepared. Actual work on preparation of the budget varies according to the size of the city, but should start not less than two months before the end of the fiscal year.

In Pasadena the Controller prepares the budget forms in quadruplicate. These contain a statement in detail of the current year's appropriations and the expenditures incurred during the first nine months of the fiscal year as a basis for departmental estimates. Uniform classification of expense greatly facilitates the preparation and consideration of the budget. These forms are delivered to the heads of the several departments who insert their department requests. The requests are then summarized and passed to the City Manager for consideration along with comparative figures and estimated revenues. After the budget has been adjusted to the point where the expenditures are not in excess of the estimated revenues it is passed to the Board of Directors for approval.

The revenues of the City are estimated by the Controller, with the assistance of department heads. The amount to be derived from taxes can be accurately determined, but miscellaneous revenues should not be overestimated if these form a substantial part of the funds necessary to run the City. During the year emergencies may arise which were unforeseen at the time the budget was

adopted, and the problem arises as to how to meet the emergency. This reminds me of the last Christmas party for municipal employees, at which some one kindly fixed up a stocking for me with a little note addressed to Santa Claus which read. "Please bring me a big budget; one that will stretch." If miscellaneous revenues are overestimated the budget can not stretch, as the only place from which additional appropriations can be made is by cutting down appropriations in one department to provide for expense in another.

However, we must provide a surplus in the budget with which to sail on into the next fiscal year, as miscellaneous revenues are not sufficient to meet the expenses of the first four months prior to collection of taxes. This surplus might be drawn upon in emergency but, owing to the continued growth of the City, it is advisable to build this up rather than deplete the fund.

Upon approval by the Board of Directors each department head is furnished with a copy of his budget, and it becomes his duty and the duty of the Auditor and the City Manager to see to it that the budget is strictly adhered to.

Budget Control

In controlling the receipts of cash the plan followed in the City of Pasadena serves as a good auditing basis, as every document passed to the Cashier for payment is controlled by a corresponding revenue document, which becomes a charge to Accounts Receivable. All cash coming into the City Treasury passes through the Cashier's window and in every instance is supported by a cashier's stub with number corresponding to the revenue account to which the amount has been credited, a stub or duplicate being a part of each invoice when it is prepared.

In controlling the expenditures it is important to know whether funds are available before the expenditure is made, and not to wait until the invoice comes in before determining whether a department has funds with which to meet the obligation.

A number of smaller cities are still maintaining their accounting records on the receipts-and-disbursements plan—accounting credits to departments when the cash is received and only charging departmental appropriations when the cash is disbursed. The old adage, "An ounce of prevention is worth a pound of cure," holds very true in city finances. Before expense is incurred it is essential to prevent overdrafts by determining that funds are available to meet the obligation.

The City of Pasadena accounting records are maintained on a revenue-and-expenditure basis. When service is rendered by the City, Accounts Receivable Account is charged and Revenue or Income Account is credited. Departmental appropriation accounts are charged as soon as purchase orders are issued, the estimated amount of the purchase being set up as an encumbrance of the appropriation; no purchase order being issued if the Department has not sufficient funds to cover the order.

These records are maintained in the appropriation ledger, which has separate sheets for salaries and expense items. When the invoice is presented and audited the actual amount of charge is posted and the estimated amount cancelled, so that at all times the appropriation ledger shows the current available balance. The appropriation ledger is posted on a Burroughs machine, but the work was formerly all done with pen and ink. Further details of expenditures and balances are maintained in the Analysis of Expenditures, which is kept in Kardex cabinets with colored signals denoting the status of the accounts. By the aid of these records we can determine the financial course we are sailing and how close we are following our budget compass.

Budget control does not necessarily mean that a department must be compelled to keep within the limits of each specific appropriation, but it does mean that a department must not exceed the total appropriation provided, and this can best be controlled by prompt posting, as stated, and by careful analysis of the expenditures. Purchase orders for "Additions to Properties," such as purchase of equipment, etc., must only be approved if provision has been made for each item in the budget. Here the Controller must also see that, if orders for equipment are placed before tax collections come in, arrangements are made for payment at future dates, as the surplus is not ordinarily sufficient to meet these payments. Purchase of supplies can be readily checked by comparing the expenditures with the proportionate part of the budget allowance for the period of the year which has elapsed.

Payroll expenditures can be controlled by the use of salary notices indicating the rate of pay of each individual employed

and having the approvals of Heads of Departments, City Controller and City Manager. A monthly report should also be presented to the City Manager showing the amount paid and number of employees in each department as compared with the previous year and previous month.

In addition to the daily information regarding the financial condition of all departments, monthly reports should be presented to the heads of departments, the City Manager and the Board of Directors, and their attention is called to any excessive expenditure or decrease in revenue.

The use of graphs or charts is of great assistance to the Controller in presenting the status of budget estimated revenues and appropriations as compared with actual income and expense or previous year's totals; also the rise and fall of the general fund balance, receipts and disbursements.

Auditing efficiency is like searching for the pot of gold at the end of the rainbow; it is worth seeking but it is never reached, as one efficient step leads to another.

PREVENTION OF DEPOSIT IN WATER MAINS

By William Ransom, City Surveyor of Worcester, England.

(Presented at West Midland District meeting of the Institution of Municipal and County Engineers held at Birmingham, England in November, 1925.)

The water engineer has many problems to solve when undertaking to provide the public with an adequate domestic supply of water, for not only has he to purify the water, but he has to see that it is adequately distributed at the necessary pressure.

The area of supply is constantly increasing and extending beyond the original limits. Water mains which were originally large enough to supply the various districts become inadequate, and complaints of poor supply and pressure have to be met by enlarging the mains.

The mains and services, too, become incrusted or filled with deposit, and so impede the normal supply of water that the quantity of water that can be delivered through the mains is but a small proportion of that for which they were designed.

As the inner surface of the mains becomes rougher by incrustation or deposit, the additional friction causes an increasing loss of head. The incrustation of water mains has therefore a great bearing upon the financial side of a water undertaking. The renewal of water mains in these days of high prices is a very important item, and anything that can be done to prevent incrustation or deposit, and so prolong the effective life of water mains, will defer a large capital outlay.

During recent years many water mains have been renewed so as to relieve unemployment. The demand for pipes has exhausted stocks, and in some cases pipes have been laid where the preservative coating has not been thoroughly dry or properly hardened before being laid in the trenches.

Complaints have arisen, especially after hot weather, as to a tarry flavour being imparted to the water, and the only remedy appears to frequently flush the new length of mains.

It is not proposed to deal in this short paper with the ordinary forms of incrustation due to corrosion or to a graphitic change in the metal, but rather with the causes of deposit other than active corrosion.

Causes of Incrustation

Water mains can have their waterway almost filled up by incrustation and deposits, caused by chemical or electrical actions, but deposits are also formed by means of microscopical organisms.

One of the causes of deposit and discoloration in water is the presence of an excess amount of carbon dioxide. If the iron be not protected, the metal is attacked, and produces a ferrous carbonate, which in the presence of water containing carbon dioxide will remain soluble.

When this ferrous carbonate is able to absorb oxygen a brown hydrate is deposited. If this absorption occurs in the water main a deposit is formed in the pipes which will quickly choke the mains if not removed by flushing or scraping. If the ferrous carbonate be passed on to the consumer, oxygen will be absorbed from the atmosphere and, after the water has first become turbid, a brown hydrate will be deposited, discoloring all utensils with which it comes in contact.

Waters of this nature present a serious problem to the engineer, for choking of the mains and services will be continually taking place, and the only real remedy is to remove the carbon dioxide. This can be effected by aerating the water in the

presence of substances able to absorb the carbon dioxide.

The inner surface of the water mains should be protected as much as possible so as to minimize the contact between carbon dioxide and the metal, and to prevent ordinary forms of corrosion. A cement lining to cast-iron pipes will afford an adequate protection, but the ordinary means of protection is to dip the pipes into Dr. Angus Smith's preparation, which consists of a mixture of coal tar or pitch oils and rosin.

The process is described in the British Standards Specification as follows:

"The casting shall be heated to a suitable temperature not exceeding 250 deg. Fahr., and perfectly coated in the most approved manner by being dipped in a bath of approved composition maintained at a temperature of not less than 300 deg. Fahr., not more than 330 deg. Fahr., according to Dr. Angus Smith's process.

"When the pipe is removed from the bath it shall be properly drained, and the coating must fume freely and set hard within an hour.

"If the coating does not so fume the pipe should be recoated."

Cement-lined pipes are coming increasingly into use, and provide a non-corrosive face internally with the full strength of a cast-iron pipe. The centrifugal casting of pipes, which is used to produce the Delavand pipe, gives a much harder pipe, and one less liable to corrosion, than the ordinary cast-iron pipe.

Deposits are sometimes caused in mains by sand and small gravel being carried from the filters. This is due to faulty filtration by placing too much pressure upon the filters. Carelessness in main laying or service laying will sometimes admit gravel or sand into the mains, causing dislocation of domestic supplies.

Hard waters will, of course, cause deposits of calcium carbonate, but these waters can be treated satisfactorily by one of the well-known processes of water softening.

Other deposits are found in water mains which are varied and complex, and in the majority of cases are due to the action of iron bacteria.

Iron Bacteria

Iron bacteria have a great influence upon deposits formed in pipes. Their life history has been closely studied by Dr. David Ellis, and he has classified those which chiefly affect the water engineer as follows:

1. Leptothrix ochracea.
2. Gallionella ferruginea.
3. Cladothrix dichotoma.
4. Crenothrix polyspora.
5. Spirophyllum ferrugenium.

These bacteria all require organic matter to enable them to thrive and, while absorbing this pabulum iron is deposited in the sheaths or coating of the organism. While the supply of food lasts the organisms multiply rapidly, but with the removal or exhaustion of the food the organisms die down, leaving their iron-impregnated casings to be deposited in the mains or reservoir.

Acid waters are found to be more favorable to the growth of the organisms, so that water from moorlands and peaty districts are especially liable to be affected by the growth of iron bacteria.

Alkaline waters give a certain amount of protection from such bacterial action.

Slimy growths of a long, sinuous nature are produced by the iron bacteria, especially gallionella and spirophyllum, and are found in reservoirs as well as the mains.

The presence of iron is not essential to the growth of these organisms, but where iron is present it is absorbed and subsequently deposited.

Iron bacteria have an indirect influence upon the corrosion of iron mains, as they may help in the oxidation of the iron by introducing carbon dioxides. Chemical and electrical actions are primarily responsible for incrustation, but corrosive action may be aggravated and accentuated by the presence of the iron bacteria.

Bacterial growth of iron organisms in reservoirs should therefore be guarded against, as an attacking agency may be introduced into the water mains which will increase the corrosion of the iron and cause deposits consisting of the dead organisms, which in time will help to perpetuate the bacterial growth by providing the food for succeeding generations of bacteria which may be introduced into the mains.

The growth of algae in reservoirs should be checked, as the vegetation may become detached and pass into the main. If the water be treated with a copper sulphate solution the growth of the algae can be kept in hand.

In this country it is seldom necessary

to provide an iron removal plant. The mere presence of iron is not sufficient for the development of the iron bacteria. There must be organic matter, and where there has been efficient purification little opportunity is given for the development of iron bacteria. In America, where drift water is sometimes used for domestic purposes, iron is present to an appreciable extent, and special means have to be adopted for its removal. The crenothrix organisms develop rapidly, and the dripping of the water gives a stain to porcelain and other material. This organism has been studied by many investigators in Germany and America. In connection with the Rotterdam water supply, which was badly affected with this growth, a commission appointed by the city authorities reported that the organism is one of the largest in the whole group of bacteria. Although the cells are invisible to the naked eye, they are united end to end as to form threads or filaments, which in turn tend to make flocks or masses visible to the naked eye.

The presence of iron in the water was formerly thought to be necessary to the life of the organism, but investigators are now of the opinion that this is not the case, but that in the presence of iron the organism can absorb the mineral into its sheath or outer covering and upon the death of the organisms a slimy gelatinous matter is deposited, consisting of iron and dead organic matter.

In America the method adopted for the removal of iron consists in aeration and intensive sand filtration. The raw water is saturated with oxygen and then filtered through coarse sand, which has to be regularly washed to restore its filtering properties.

The prevention of deposits due to iron is most effectually done by efficient filtration, which by removal of the pabulum or organic matter will prevent the development of the iron bacteria.

The presence of iron in the water apart from deposit is, of course, highly objectionable from a domestic point of view for plumbing fixtures become stained, linen becomes iron-moulded, and a disagreeable smell and flavor are often imparted to the water.

Complaints are sometimes received that small worms have passed through the taps and are being delivered to the consumer. There is no evidence that these have come from the mains. Dr. Houston is of the opinion that they have travelled up the tap upon the consumer's premises and become dislodged upon a discharge of the water.

It would be an interesting point of investigation whether the use of leather washers has any effect upon the water and if the leather affords a breeding ground for the development of micro-organisms.

ECONOMICS OF STRENGTHENING AND WIDENING PAVEMENTS

By W. H. Connell, Engineering Executive and Acting Secretary of Highways, Pennsylvania Department of Highways, Harrisburg, Pa.

(Presented at 1925 meeting, at Detroit, of American Association of State Highway Officials.)

The economics of strengthening and widening of pavements, while not a new highway problem, is more or less new in so far as the State Highway Departments are concerned. This is a problem which the cities, particularly the larger ones, have been wrestling with for a number of years, whereas the highway problem of the State Highway Systems has been more or less confined to constructing new pavements of a width and strength adequate for the traffic needs. The designs of the present day, in so far as the strength is concerned, are based on the estimated future traffic needs for a long period of time, while the width in many instances is based only on the present and estimated future traffic needs for a few years hence. This is due to the fact that the general policy has been not to make the pavements any wider than was absolutely necessary until the entire highway systems are continuously improved. This is a very proper policy as a paved, connected highway transportation system in every state is of first importance. This justifies constructing pavements of a width of 18 ft., in many instances where 30 or 40 ft. would be preferable. When the highway systems are continuously improved, it is perfectly practicable to widen the pavements when necessary and as the funds become available.

Traffic Capacity of Highways

As a matter of fact, an 18-ft. pavement has a very considerable traffic capacity. In a paper read before the American Society of Civil Engineers in December, 1924, by Mr. A. N. Johnson, Dean of the University of Maryland, it was shown from actual traffic investigations made in Maryland that a two-lane road would

carry as great as 1,000 vehicles per hour without inconvenience to mixed traffic, the faster traffic having opportunity to overtake and pass the slower moving vehicles, and that for occasional peak traffic it will discharge readily with traffic moving at an average speed of 25 miles per hour at least to 1,600 vehicles per hour. The forenoon and afternoon peak traffic on the roads on which these investigations were made was 30 per cent to 50 per cent more than the average hourly traffic for the day. Thus, if 1,000 vehicles represented the peak hourly traffic, the average daily traffic would be 7,200 vehicles for a 12-hour day, and with a peak hourly traffic of 1,600 vehicles, the average daily traffic would be 11,500 vehicles for a 12-hour day, which could be accommodated on a two-lane road without congestion occurring.

Strength and Economics

Pavements, however, in each instance, should be constructed of a strength that will be adequate to take care of the estimated future traffic needs for a stated pe riod, based upon the estimated economic life of the different types of pavement under specific traffic conditions. The economic pavement for each situation is the pavement that will adequately serve the traffic needs for the least annual cost.

The annual cost in each instance embraces the interest and sinking fund on the capital outlay and the annual maintenance charges, minus the saving in operating cost on the present highway. The factors affecting the operating costs are the difference in distance, line, grade and road surfaces between the two highways. In some instances, the present and estimated future traffic on outlying highways doets not justify an expenditure for any kind of a road surfacing, while in other cases the economic surfacing for the estimated future traffic over a stated period of years might be gravel, bituminous surface-treated macadam, penetration macadam, bituminous concrete on a stone base or a durable type of construction, which will be defined as a concrete pavement or a pavement having a concrete foundation. It would not be an economy to construct one of the flexible types of pavement, even though it might serve the immediate traffic needs, in instances where the estimated future traffic will consist of a considerable amount of heavy truck loads in sufficient numbers to destroy the pavement prior to the expiration of its economic life. For example, a pavement of this type might serve the present-day traffic for the least annual cost for a period of 15 to 20 years, whereas if the traffic about 5 or 10 years after the construction of the pavement was too heavy for the type constructed, destruction of the pavement by this traffic would result in an annual cost during its life that would be greater than the annual cost of a more expensive durable type of construction of sufficient strength to serve this traffic for the same period of time. Likewise, an expensive durable type of construction would not be the economic pavement in instances where one of the less costly types of construction would serve the traffic needs for a stated number of years at a less annual cost than the durable type.

The kind of analysis that should be made before determining upon the strength and width of pavement in each instance makes it necessary to have sufficient data at hand to estimate the volume and character of the traffic that the pavement will be required to serve for a period of years. The present traffic can be obtained through a count, but an intelligent estimate of the future traffic must be based upon a study of the territory served by the proposed transportation system of which the highway under consideration is a part.

The character and volume of the traffic on roads that compose a highway system will vary in proportion to the population and pursuits of the population that each section of highway serves. In communities where the population and its pursuits are similar, the traffic is likely to be the same both in character and volume, but where the highway serves communities of like population but with different pursuits the character of the traffic will vary. For instance, there may be the same volume of traffic on a highway serving a popular summer resort as on a highway in the vicinity of coal mines, or in a community in which there are several industrial or manufacturing plants. In the latter two cases, however, there would in all probability be a considerable number while there would be only a small num- of heavy truck loads using the highway ber of heavy truck loads using the highway serving the summer resort and only during the summer season, so that in all likelihood the economic pavement for the highway serving a summer resort would not be of sufficient strength to be the economic pavement for the highway serving

the industrial and manufacturing communities or the coal mines.

It is necessary, therfore, to have data indicating the physical characteristics of all the sections served by the highway system, industrial, manufacturing, mining, resort areas, etc., population and its pursuits of the different communities and sections served, location of the railroads with respect to the highways, and all other pertinent information that will affect the highway traffic. These considerations are just as important factors affecting the proposed strengthening and widening of pavements as in the original construction.

This basic information was obtained in Pennsylvania in the Highway Transport Survey started in 1923, and through the data at hand it has been possible during the past three years for the Department to operate on a practical and sound economic basis in determining upon the strength and width of pavements constructed on the Pennsylvania Highway System. This has embraced not only the construction of new pavements, but also the thickening and widening of several types of existing pavements.

The underlying principles governing the determination of the strengthening of an existing pavement are exactly the same as the principles involved in determining upon the strength of the original pavement. The economic width of a pavement that requires widening likewise involves the same principles as those applied to the determination of the width of the original construction, with this notable exception: Until the highway system is completed, a width of two traffic lanes, of 9 or 10 ft. each, or an 18 or 20-ft. pavement, will in most instances carry the traffic over the road but not at as desirable a speed and with the same measure of safety on a heavy traffic road as a wider pavement, so that while the economic width until the system is completed, on certain highways might be 18 or 20 ft., the economic width on the same highways, after the system is completed and when there are funds available, would be three or four traffic lanes of 9 or 10 ft. each, preferably 10 ft., or a pavement of a width of 30 or 40 ft.

Strengthening and Widening in Pennsylvania

On the Pennsylvania Highway System there are both flexible and durable types of construction and a considerable mileage of the flexible type of construction is strengthened every year. There are also instances where the durable type of construction is strengthened. The durable types, of course, are comparatively new, but as time passes there will be a very great mileage of these types which will require strengthening.

The methods used in strengthening the flexible types are more or less standard and have been for a number of years. The practice in Pennsylvania, based on the economics in each individual instance, is briefly as follows:

When a gravel or an oilbound stone road (which is a pavement consisting of from 3 to 6 ins. of stone without screenings and annual applications of cold tar) requires strengthening and a bituminous surface-treated macadam resurfacing is adequate for the estimated future traffic, such a surfacing is determined upon, and in most instances this is the case with these types of roads because they are usually in the outlying sections where there is very little traffic or little likelihood of traffic.

When biutminous surface-treated macadam roads require strengthening, in most cases the estimated future traffic requirements indicate that a stronger type is necessary. In some cases a penetration macadam or bituminous concrete surfacing will be sufficient, while in others a replacement with a durable type or widening with a durable type on the dual type plan are the logical solutions.

Where the replacement plan is adopted and the indications are that the increased traffic will consist of any appreciable amount of heavy trucking, concrete pavement is specified, and likewise in widening with the durable type where it is expected there will be any appreciable amount of heavy trucking, the widening consists of concrete slabs.

Where the traffic is heavy in volume but does not consist of any appreciable amount of heavy trucking, the widening consists of concrete slabs.

Where the traffic is heavy in volume but does not consist of any appreciable amount of heavy truck loads, sheet asphalt or bituminous concrete on a concrete base can also be used.

Strengthening ..and ..Widening ..Durable Types in Pennsylvania

Route 1, Lincoln Highway—In Malvern Borough, Chester County, a section of this highway 2,701 ft. in length was constructed during 1918 with reinforced con-

crete, 1-2-3 mixture, 16 ft. in width, 5 ins. in depth at the side and 7 ins. in depth at the center, with flat subgrade. The reinforcing on this pavement is 25-lb. fabric placed 2 ins. below the surface of the pavement, and the length of constructed slabs was 40 ft., with pre-moulded expansion material between the slabs. The average daily summer traffic for 1924 was about 3,250 vehicles, of which about 350 were trucks. The average yearly daily traffic for 1924 was about 2,500 vehicles, of which about 262 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic.

On account of the restricted width and the heavy traffic, during 1923 it was found necessary both to widen the pavement and to strengthen the edges where a number of corner breaks had occurred. This was accomplished by placing a strip of concrete, 2 ft. in width, along each edge of the pavement. The cross section used was 10 ins. in depth at the outer edge with horizontal subgrade carried under the edge of the old pavement for a width of 6 ins. and for a depth of 6 ins. under the edge of the old pavement. Two ⅝ in. square deformed bars were placed 2 ins. from the bottom of the section at distances 4 and 16 ins. from the outer edge.

The highway has been under traffic two years since the edges have been widened and strengthened, and there have been no evidences of failure of either the old pavement or the widened section.

Route 9, Yellowstone Trail—On this main highway between Cleveland and Buffalo, immediately west of the city of Erie, a section 13,750 ft. in length was constructed during 1918 with 1-2-3 reinforced concrete, 16 ft. in width, 5 ins. in depth at the side, 7 ins. in depth at the center, with flat subgrade, reinforced with 25 lb. fabric, placed 2 ins. below the surface. Pre-moulded expansion joints were placed every 40 ft.

The average daily summer traffic for 1924, was 4,300 vehicles, of which 268 were trucks. The average yearly daily traffic for 1924 was 3,000 vehicles, of which 135 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic.

An effort was made to maintain suitable shoulders with gravel, which, on account of the restricted width, was not economical and, during 1923, it was found necessary to widen the pavement to 24 ft., and to strengthen the edges on account of a considerable number of corner breaks which had occurred. The cross section of the widening on each side was a slab 4 ft. in width from the edge of the old pavement, 8 ins. in depth, uniformly from the outer edge to a point within 12 ins. of the edge of the old slab where the depth was increased 4 ins. and carried under the edge of the old pavement slab for a distance of 6 ins. and a depth of 7 ins. making the total depth of new and old concrete on the edge 12 ins. This slab, which consisted of 1-2-3 concrete, was reinforced with bars placed 2 ins. below the surface of the pavement, two of which were spaced 4 ins. and 12 ins. from the outer edge, and one spaced 4 ins. from the inner edge of the new slab.

The improvement has been under traffic for two years, and there has been no failure of either the old pavement or the new.

Route 69, Armstrong County—On this main highway between Kittanning and Pittsburgh, a brick section, 11,515 ft. in length, was constructed in 1912, 14 ft. in width, including a 12-in. flush concrete header curb on each side. The base was composed of crushed stone 6 ins. in depth.

The average daily summer traffic for 1924 was 800 vehicles, of which 50 were trucks. The average yearly daily traffic for 1924 was 500 vehicles, of which 40 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic.

Due to the restricted width and heavy depth of sand bed, the brick surface had become quite irregular, so that the bricks in many instances were broken and in general were not worth salvaging. The whole pavement was resurfaced with concrete in 1924, widening it uniformly 2 ft. on either side to provide a standard pavement, 18 ft. in width. The new paving section was placed directly on the old brick paving but the top of the header curb was beveled off toward the outer edge. The concrete slab over the brick was constructed with a practical minimum depth of 5 ins. and the 2 ft. widened strip on each side was made uniformly 9 ins. in depth. The slab was reinforced with 65-lb. fabric, with the heavier members placed transverse to the center of the pavement.

This section of highway was constructed without center joint with transverse joints approximately 150 ft. apart, and there are very few cracks of any kind in it and none over the edge of the old pavement.

Route 4, Susquehanna Trail—In Lycoming County, adjacent to the east city line of Williamsport, a section of brick pavement, 2,664 ft. in length with 2-in. sand cushion on a 6-in. base of 1-3-6 concrete was constructed in 1907. The section of pavement was 30 ft. in width with a single track street railway in the center, occupying a section 7 ft. in width, which paving was separate from the remainder. A stone curb was constructed along the outer edges.

The average daily summer traffic for 1924 was 3,500 vehicles, of which 244 were trucks. The average yearly daily traffic for 1924 was 2,500 vehicles, of which 206 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic.

The old pavement had become very rough due to the irregular hardness of the brick and the excessive depth of sand cushion. It was decided, in 1923, to resurface this section with reinforced concrete, replacing the old brick and sand cushion with a slab 6 ins. in depth. Sixty-five pound reinforcing fabric was placed 2 ins. below the surface of the finished pavement with the heavy members longitudinal with the center of the pavement, and construction joints were placed at about 50-ft. intervals. The work was done independently of the street car section.

This section of pavement has been satisfactory, indicating no inherent weaknesses. The resurfacing is of a greater depth than would ordinarily be used on account of conforming to the existing structures.

Route 221—In Blair County, adjacent to the city of Altoona, on what is known as the Buckhorn Road, which is subject to heavy coal hauling from mines in the mountains to the city for domestic consumption, the Department constructed in 1913 a section of pavement 26,624 ft. in length, 16 ft. in width, the surface being asphaltic concrete, 2 in. in depth, with 12-in. header curb on either side, and a 5-in. base of 1-3-6 concrete.

The average daily summer traffic for 1924 was 938 vehicles, of which 274 were trucks, including many 26,000 lb. loads. The average yearly daily traffic was 664 vehicles, of which 208 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic.

On account of the great predominance of heavy coal trucking towards Altoona, the old pavement was broken down and from time to time has been partially replaced. During 1924, a contract was let for the resurfacing of 12,751 ft. of the pavement, consisting of a minimum depth of slab of 5 ins. placed on the old concrete base, excepting 2,000 ft. where the minimum depth of slab is being constructed 4 ins. in depth. The old header curb was split off to the elevation of the top of the old base. The pavement was widened to 18 ft. and is being constructed with a longitudinal center joint. The additional width is being built entirely on one side. The pavement is being reinforced with 42 lb. fabric with heavy members laid transversely 2 ins. from the surface of the pavement and a ¾ in. round deformed marginal bar placed 4 ins. from either edge and 4 ins. from the center joint on each half-section of pavement, and laid immediately below the fabric reinforcing. The outer edge of the pavement beyond the old base course is carried to the depth of the bottom of the old base course, and is, therefore, 10 ins. in depth where the center slab is 5 ins. in depth and 9 ins. in depth where the center slab is 4 ins. in depth.

This resurfacing is now under construction and due to the fact that there are no available detours, traffic is being handled and the construction done in half widths. The 4-in. slab construction on this project is the minimum depth of concrete resurfacing that has been used in this State, and due to the heavy truck loads, we will soon be able to judge the durability of the pavement.

Route 1, Lincoln Highway—In Bucks County, between Philadelphia and Trenton, New Jersey, a section of highway 2,440 ft. in length was built in 1919 by the Pennsylvania Railroad as part of a grade crossing elimination project.

The pavement consists of a section 19 ft. in width with 2½ ins. of bituminous surface on a concrete base 6 ins. in depth at the edges with flat subgrade and a 12-in. flush header curb on each side. The base was constructed with poured expansion joints at approximately 30-ft. intervals.

The average daily summer traffic for 1924 was 8,600 vehicles, of which 1,050 were trucks. The average yearly daily traffic was 6,677 vehicles, of which 888 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic.

The old pavement was more or less dilapidated due to poor drainage. It was resurfaced with reinforced concrete, a

minimum depth of 5 ins. being placed over the old bituminous surface. The header curb was split off and a 6-in. widening outside of the old section on either side was carried to the bottom of the base course, or a total of 1 ft. and 1 in. in depth. The reinforcing consists of 65-lb fabric with main members laid transversely and ¾-in. round deformed marginal bars 2 ins. below the finished surface and 4 ins. in from the outer edge and from the longitudinal construction joint in the center. One-half inch square steel dowels 4 ft. in length were carried through the longitudinal center joint tying the slabs together.

This section of highway was recently completed and was constructed in half width, carrying the heavy Lincoln Highway traffic continuously. While the first half was being constructed and traffic was using the other half of the old road there was considerable vibration of the new concrete which has resulted in a great many fine irregular cracks in the pavement slabs which do not appear in the half of the pavement built last, when traffic was passing over the new concrete section. The effect this condition may have on the life of the pavement will be observed with considerable interest.

Route 1, Lincoln Highway—Immediately west of Philadelphia, in Delaware, Montgomery and Chester Counties, the old macadam turnpike was reconstructed into a broken stone base course and surfaced with a 2½ in. sheet asphalt wearing surface in 1918 for a length of five miles adjacent to Philadelphia. During the following year nine miles more were reconstructed in a similar manner except that the surfacing was a 2-in. asphaltic concrete modified Topeka mixture.

The average daily summer traffic for 1924 was 7,500 vehicle, of which 900 were trucks. The average yearly daily traffic for 1924 was 5,400 vehicles, of which 600 were trucks. It is estimated the traffic in ten years hence will be about double the present traffic.

The surface on these sections was placed 18 ft. in width and considerable stone from the oldturnpike was left in the shoulders. The development along this section of highway is mainly residential, but there are also large schools and towns of considerable size. Some sections of the sheet asphalt and considerably more of the asphaltic concrete have been patched with asphaltic concrete, but the pavement as a whole is in fairly good condition.

It was decided during the present year to widen this pavement for a distance of approximately ten miles west from Philadelphia, providing four traffic lanes, each 10 ft. in width. This is being accomplished by constructing a new reinforced concrete slab 10 ft. in width on either side with a 6-in. high curb, leaving the present pavement in the center, thus obtaining the full salvage value of it, and placing a 1-ft. strip between the new concrete lanes and the original 18-ft. pavement with sheet asphalt upon a concrete foundation. Over the major length of this section traffic is being maintained during construction.

The section being used for the new concrete lanes is 6½ ins. in depth at the edge adjacent to the bituminous pavement and the 8 ins. in depth under the curb, the top surface and bottom surface of the concrete conforming to parabolas.

A 6-in. curb on the outer edge is cast monolithically with the concrete pavement. Reinforcing consists of marginal bars, one being used 2 ins. below the surface and 4 ins. in from the thin edge, and two being used 2 ins. below the concrete surface, 4 ins. and 12 ins. respectively, in from the outer edge of the pavement.

The grading, drainage and concrete paving are being done by contract. and the necessary repairs to the bituminous pavement in the center are being done by the Department's forces.

Route 1, Lincoln Highway—In Chester County, from the Borough of Downingtown eastward, the highway has been maintained as a bituminous surface-treated macadam pavement for the past ten years. It was formerly an old stone toll road. It was generally about 18 ft. in width and the foundation was good, this being one of the oldest highways in the country.

The average daily summer traffic for 1924 was about 4,300 vehicles, of which about 260 were trucks. The average yearly daily traffic for 1924 was about 3,000 vehicles, of which about 250 were trucks. It is estimated that the traffic ten years hence will be about double the present traffic. This section of highway was maintained as a bituminous surface-treated macadam until this year when it required reconstruction or resurfacing. It is now being widened on the dual type pian.

This method consists of preserving a 10-ft. width of the old macadam surface in the center. Two new 10-ft. reinforced concrete slabs will be constructed, one on

either side, giving a highway width of 30 ft. with concrete for continuous traffic and the center madadam strip for passing. The concrete slabs are 6½ ins. in depth adjacent to the macadam and 8 ins. in depth at the outer edge, reinforced with ¾-in. diameter round deformed bars placed 2 ins. below the finished surface, one being placed 4 ins. in from the thin edge and two being placed 4 ins. and 12 ins., respectively, in from the thickened edge. The top and bottom of the slabs conform to parabolas.

The grading, drainage and concrete paving are being done by contract, and the necessary repairs to the bituminous surface-treated macadam in the center are being done by the Department's forces.

General Methods of Strengthening and Widening of Durable Types

The strengthening and widening of durable type construction in cities has in most instances usually consisted of, where just strengthening was concerned, increasing the thickness of the concrete foundations or replacing an asphalt or brick pavement on a concrete foundation with a granite block pavement on the same foundation. Granite block is the heavy traffic pavement in most large cities: The widening of the pavement in cities has usually consisted of annexing part of the sidewalk area for the paved roadway, and generally the same type of pavement as the existing pavement has been used.

In so far as State Highways are concerned, the strengthening and widening of durable type construction, while a new problem, deserves the greatest consideration, as it will be a most important factor in the future highway work when the present more or less new durable type pavements age and the traffic increases.

In a number of instances concrete pavements that have shown the effect of wear have been given bituminous surface treatments and also have been surfaced either with sheet asphalt or bituminous concrete. The bituminous surface treatments, however, are more in the nature of maintenance, or prolonging the life of the existing pavement, and could not be considered as methods of strengthening the existing pavement to carry heavier traffic than that for which the original pavement was designed. Sheet asphalt and bituminous concrete surfacing add strength to the pavement and prolong the life of the original construction, but the problem of the future is not only going to be to strengthen the pavement to a modified degree and to prolong the life of the existing pavement, the real problem will be to strengthen the existing pavement to carry considerably heavier loads than those for which it was originally designed. This will necessitate adding to the thickness of the durable construction whether it be a concrete pavement or another type on a concrete base.

A survey of what has been done in this respect indicates that the strengthening of the durable type construction, whether it is a concrete pavement or a sheet asphalt or bituminous concrete or brick pavement on a concrete base, has consisted of surfacing the existing pavement with a concrete slab from 2 to 7 in. thickness.

The following is a number of the specific instances where this character of work has been done showing the date, thickness and method of resurfacing, also the present condition of the pavement. These data are not the result of a personal inspection, but as reported by the authorities in charge or other engineers who have made personal inspections, the accuracy of the statement relative to design, methods, thickness and present condition, therefore, no doubt in some instances, is subject to correction and will be corrected upon information from the responsible officials in the localities referred to.

Strengthening and Widening Durable Types in the United States

California State Highway, Resurfacing Since 1918—For a number of years the standard surface for state highways in California was a concrete slab 4 ins. thick mixed 1:2½:5. In 1917 this mixture was changed to 1:2:4, and in 1920 the thickness was increased to 5 ins., and still later to 6 ins.

A great many miles of these old concrete roads have been resurfaced and widened by building a 2½-ft. concrete shoulder on both sides of the old 15-ft. pavement and by placing a new 4-in. concrete slab on the old pavement, the new slab being monolithic with the new shoulders. One-quarter inch reinforcing rods on 18-in. centers were placed in the middepth of the resurfacing slab transversely and extend across the shoulders. In some cases the new shoulder and resurfacing were laid on one side of the center line at a time and traffic used the other side.

In a number of other instances the 4-in. pavement was resurfaced and widened to

20 ft., the resurfacing being 6 ins. thick at the center, 7 ins. thick at the edge of the old base, and thickened to 9 ins. at the outer edge. Three-eighth inch deformed reinforcing bars 4 ft. long were placed transversely in the widened strip and extending into the resurfacing over the old base and other bars were placed longitudinally 6 ins. and 4 ft. from the outer edge, thus forming a steel mat in the widened section extending across the edge of the old base.

These pavements are reported to be giving satisfactory service. There is a very considerable mileage of resurfacing by these two methods in California.

A number of the counties have also done considerable concrete resurfacing on old concrete pavements and the thickness of the resurfacing has been from 4 ins. to 7 ins. and the methods are somewhat similar to those described in the state work.

Boston Post Road, West Haven, adjoining West River—Reinforced concrete resurfacing 4 ins. thick over the old road, 9 ins. thick in additional width, 79-lb. mesh. Constructed in 1921. At present it is reported in excellent condition and although on close inspection it is possible to find very fine cracks, none of these have yet been mentioned, nor would they warrant it. Connecticut State Highway Department can give details of construction.

Warsaw Street, Toledo, Ohio—A short section of concrete road built in 1912 was damaged by frost. In the spring of 1913 the original surface was carefully cleaned, covered with dry cement, which was sprinkled with water and worked up with wire brooms into a neat cement grout. A new concrete surface was then placed, using a maximum of ¾-in. size stone, the thickness of the resurfacing varying from 1 in. at the edge of the road to 2 ins. at the center, the pavement being 26 ft. wide. A very light wire mesh was placed in the resurfacing. This road was reported to be in first-class condition in 1923, after ten years of service. Information by L. T. Owen, City Engineer, Toledo, Ohio.

West Market Street, Savannah, Missouri, was paved in 1914 with an asphalt surface on a concrete base. Due to improper construction the surface disintegrated within a few months. In 1915 the surface was removed and replaced with a concrete surface, 2 ins. thick at the sides and 3 ins. thick at the center, a light steel mesh reinforcement being used. This job is reported to be in first-class condition after ten years of service, although the character of the work was not such as to produce a good riding surface.

North John Street, Aylmer, Ontario, Canada—A concrete pavement poorly built in 1912 was resurfaced in 1915 with a layer of reinforced concrete 2 ins. thick at the gutter lines and 3 ins. thick at the center.

Reports in 1924 show this pavement in good condition, after nine years of service. There has been no separation in the slabs and there has been practically no maintenance charge on the pavement. Information by W. E. Stewart, Aylmer, Ontario.

Bridge Street, Oswego, New York—The old bituminous surface was removed from a 5-in. concrete base in 1919 and a layer of concrete reinforced with wire mesh averaging about 4 ins. in thickness was laid. This resurfacing is reported to have proved satisfactory. Reference, John T. Collins, Commissioner of Public Works, Oswego, N. Y.

Gratiot Road, Wayne County, Michigan—Laid in 1910 with 5-in. base, 1:2½:5 mix, with a Dolarway surface. This job was resurfaced in 1917 with 4 ins. of reinforced concrete pavement, at the same time being widened 20 ft. In 1923 the pavement was widened by an addition of a 10-ft. strip of concrete. At the end of eight years of service this road is in good condition, although there have been some structural failures and a small amount of maintenance required. This is a heavy traffic road. Reference—E. N. Hines, chairman, Wayne County Road Commission, Detroit, Michigan.

Ada County, Idaho—A plain concrete road built in 1913 from 4 to 5 ins. thick was resurfaced in 1920 with 3 ins. of reinforced concrete, the top of the old road being given a thin coat of Tarvia before the new surface was laid. This road is reported in good condition.

New York State two years ago resurfaced the *Syracuse-Cicero Road*, about two miles in length, with from 3 to 5 ins. of reinforced concrete. The road is reported to be in good condition. Reference—W. M. Acheson, Weigh Lock Building, Syracuse, N. Y.

Cabbott Street, Holyoke, Massachusetts—From Main Street to Canal Street a distance of 1,422 ft. was resurfaced with 3 ins. of concrete in the summer of 1924. The street is 33 ft. wide with a car line in the center. The 3-in. concrete resurfac-

ing is 12 ft. 8 ins. wide on each side of the tracks.

The resurfacing was placed on an old concrete base, 6 ins. thick, built with Rosendale (natural) cement; the surface was swept clean and wet thoroughly. Neat cement was dusted over the base and brushed in thoroughly just ahead of the new concrete. The mixture was 1:1½:3, the coarse aggregate being traprock ranging from ¼ to 1 in., and the fine containing approximately 10 per cent of stone dust. It was mixed for a full minute in a drum mixer equipped with boom and bucket.

The reinforcement consisted of ⅜ in. square deformed bars so spaced as to give 7.2 lbs. of steel to the square yard, and placed near the bottom of the new concrete. Expansion joints were spaced 100 ft. apart.

The pavement has developed transverse hair cracks at approximately 50-ft. intervals, but there is no wearing or disintegration of the concrete at these points or anywhere else.

Jefferson Street, Kirksville, Missouri—This street was originally paved with a 5-in. cement concrete foundation and a 2-in. bithulithic wearing surface. Maintenance of the original pavement was neglected and it was subject to very heavy coal hauling traffic from nearby mines consisting of 3 to 5 ton loads of coal hauled in narrow steel tired farm wagons. In 1917 it was necessary to remove the bituminous surface from the concrete base and resurface with cement concrete.

The concrete base was first thoroughly cleaned by sweeping with brooms and was then flushed with a hose stream. Dry cement was sprinkled over the wet surface and a layer of concrete, mixed 1 part of cement, 2 parts sand and 3 parts traprock was placed 4 ins. deep. A 45-lb. steel mesh reinforcement was placed in the center of this resurface layer. The new surface was finished by rolling, belting and the use of a wood float. Expansion joints were formed in the resurfacing at intervals of 40 ft.

In 1923 this pavement was reported to have carried traffic for six years without any maintenance cost. Reference—Ben Crabtree, City Engineer, Kirksville, Mo.

Description of New York State Experimental Highway No. 5470, by W. M. Acheson, Division Engineer

The old surface was built of first-class concrete in 1914 and 1915. It was placed on a clay loam subgrade and the general profile is one of easy grades over a rolling country. No real cuts were encountered and drainage was not a serious problem. The old road metal had a section of 4¾ in., 6¾-in., 4¾., being thickest in the middle and built in blocks 16 ft. wide and 30 ft. long. The sand used was one of a very fine character, and the concrete, as was then the practice, was placed very wet. This resulted in a very wavy surface. The joints were placed at right angles to the center line and were known as the "armor plate" type. These consisted of two plates of 3-16 in. metal, separated by a ¼ in. layer of bituminous felt. The plates were about 3 in. in depth and did not go to the bottom of the slab. Each plate was set in its individual slab by means of anchors about 1 ft. long and spaced about every 18 ins. It is interesting to note that while this type of joint is obsolete, very few breaks or spawls occur at the joint with the exception of corner breaks. The corner breaks are doubtless due to the fact that no reinforcement was used in the old pavement.

It was determined to resurface approximately one mile of the northern end of S. H. 5,470 as an experiment, for several reasons. One reason was that it is about the heaviest-traveled road in this section of the state, carrying over 7,500 vehicles in ten hours. Another reason was that this portion was badly cracked and warped, and only by taking the worst conditions would the experiment prove of any value.

Some time in advance of construction a crack survey was made of the proposed experiment and every crack, joint and disintegrated portion was carefully plotted to the scale of 1 in. = 10 ft. This was done mainly to ascertain if any of the cracks in the old surface would affect the resurfacing. It is proposed to repeat the crack survey at intervals and compare the most recent survey with the original. It should be noted in connection with the crack survey, that while the old surface was built in blocks 16 ft. wide, there was not a single block in a length of 5,310 ft. that did not have a longitudinal crack very nearly in the center of the block. This would seem to justify our present system of laying pavement in two longitudinal strips. The last 280 ft. were covered with a layer of bituminous material varying from ½ in. to 2 ins. in depth. As this was not removed, the cracks under it remain indeterminate. The concrete was placed directly on the bituminous carpet

to ascertain if its presence had any effect on the resurfacing.

To facilitate the keeping of records each block was given a number consecutively from 1 to 176, instead of using the ordinary method of stations every 100 ft. This is also true with the southerly 300 ft. which have been assigned alphabetical letters. Henceforth all references will be made to the number or letter of the block. As the numbers or letters were painted direcly on the old pavement, the keeping of records was made much easier.

In considering the design of the old pavement it must be borne in mind that no attempt was made to bond the old road with the new, in fact, this was not considered feasible as he old road had become oil-soaked through nearly ten years of motor travel. However, block No. 83, center strip, has no reinforcement and under this block neat cement was sprinkled lightly on the old pavement. It will be interesting to observe what will happen to this portion.

The thinnest section called for in the resurfacing is 3 in., 3¾ in., 3 in. and the thickest section 5 in., 4 in., 5 in., the middle figure referring to the center thickness in each case. These varied somewhat widely and the pavement actually ran as deep as 6¾ ins. in places where the old pavement was sagged and warped out of shape.

The reinforcement was of two types, wire mesh and bar mat, divided into separate sections.

The wire mesh reinforcement consisted of members spaced 6 ins. apart in each direction, the wires varying from No. 1 gauge to No. 8 gauge in different combinations, the longitudinal wire being heavier generally, but in some cases equal in size to the transverse wires. The weight per 100 sq. ft. varies from 42 lbs. to 78 lbs.

The bar mat reinforcing consisted of ⅜ in. diameter bars spaced from 10 to 18 ins. apart longitudinally and from 8 to 15 ins. apart transversely in various combinations, and in one case the bars of equal spacing in each direction.

The sand used was a washed variety and obtained near Cazenovia, Madison County. It is somewhat coarse, running about 60 per cent, 62 per cent by volume, through the No. 20 screen.

The stone was Onondaga limestone and obtained at Jamesville. It consisted of No. 2 stone containing about 25 per cent by weight of No. 1 stone.

The forms used were of wood and varied in thickness according to the different sections. They were fastened to the old pavement by means of pins which were driven in holes previously drilled by a pneumatic drill. To obtain a true even surface, these forms were blocked up over depressions with wooden wedges. No theoretical grade was established, the forms merely being set by eye to follow, as nearly as possible, the old surface.

Previous to resurfacing all badly disintegrated portions were removed and replaced with new concrete. These patches were allowed to dry and cure, so that no bond might be established at these points.

Just prior to laying concrete the old surface was swept clean and wet down thoroughly to aid the curing of the resurface slab as much as possible.

The types of joints used were poured and premoulded. Poured joints were used on all except the last 18 joints which were premoulded. A special device for cutting the joint material to fit the old road was devised, as all joints were set to grade so that the screed could pass directly over them.

The laying of concrete followed closely the New York State specifications which include the use of two screeds or strike-off boards. The first of these is quite heavy and shapes the concrete roughly. It is operated by four men. Two men follow with the second screed, which is lighter and is worked more rapidly than the first. In this manner the pavement has all surface voids filled quickly. The interior voids are closed by spading the concrete directly in front of the first screed. Behind the screeds two men operate what is known as the "belt". In this case a 14 in. cypress board ¼ in. in thickness was used. As soon as the concrete had set sufficiently the road was broomed with an ordinary house broom, and the edges tooled. In curing it was found that due to the old road being more or less dry, the concrete dried out at an amazing rate, and unless the burlap was applied almost as soon as the surface had been broomed, hair cracks would result. This had to be adhered to at the risk of marring the surface with the burlap. Moreover, the burlap had to be sprinkled constantly. The constant sprinkling of the burlap is important and cannot be overemphasized.

Stress has been layed thus far on the resurfaced portion, as this is the real experiment. However, mention must be

made of the widening which ran the entire length and was 8 ft. wide, making a total of 24 ft. of pavement. The widening had stretches of 8 in., 7 in., and 6 in. depths and is reinforced in a manner similar to the resurfacing, except that the southermost 300 ft. have wing bar reinforcement, a new departure in this part of the state. Aside from these points, the widening has no unusual features.

"Twenty-four hour cement" was used on the area in front of the proportioning plant and with very good results, as loaded trucks were run over it 24 hours after it was placed.

It is, of course, too early to give any definite results of the experiment as frost and snow have yet to place an undetermined strain upon it. However, a daily inspection shows no deterioration under the heavy traffic now going over it.

There are numerous other instances of resurfacing with reinforced concrete 5 to 8 ins. thick. Such slabs, however, are virtually a new pavement, but if a 5-in. slab on an old 6-in pavement will carry loads that would require an 8-in. pavement, the resurfacing is justified. If, however, the 5-in. slab on an old 6-in. pavement will only carry loads which a 6-in. pavement would carry, then it would probably be more desirable to discard the old pavement and build a new one. There is a limit to the economic maximum thickness of resurfacing with reinforced concrete as against a complete replacement of the pavement.

Conclusions

Strengthening Durable Types—These examples of strengthening durable types have been submitted as it is only through a close observation of the serviceability and annual cost of the different methods and thicknesses of surfacing that have been used that we can determine upon the economic thickness of concrete surfacing for strengthening durable type construction under varying traffic conditions.

The economic thickness of the surfacing will always be the necessary thickness to carry the estimated future traffic. There should be no skimping in the cost, nor should there be any unnecessary extravagance in the cost.

At the present day this economic thickness for given traffic conditions is far from being solved. If there could be a perfect bond between the old and new concrete so that the surfacing would simply act as part of the existing pavement in many instances a 1-in. thickness is all that would be necessary. The problem today, therefore, is to determine the minimum thickness of surfacing that will be necessary to insure that a concrete pavement of a given thickness will, after additional surfacing has been placed, carry traffic that a pavement 1, 2 or 3 ins. thicker than the original pavement would carry. In other words, if a 6-in. pavement will carry a certain load and the problem is to care for traffic that a 7-in. pavement will carry, what is the minimum thickness of concrete surfacing of the existing 6-in. pavement that will be required?

Thus far this field has been somewhat limited, and while experience of the past will be a factor in the solution of the problem, the more or less extensive exprience in this class of work in the near future will, no doubt, result in the determination of standard thicknesses of concrete surfacing for existing pavements to carry estimated traffic loads.

Widening—The widening of existing pavements is a somewhat different problem. In the course of time all the main State highway routes will have to be widened or parallel routes will have to be constructed. In most instances the existing routes will, in all probability be widened before parallel routes are constructed. Therefore, looking to the future, the first step is to provide a sufficient width of right-or-way for the future needs.

In Pennsylvania surveys are being made and plans are being filed for the ultimate width of right-of-way of the tSate highways. The width of right-of-way in each instance is based upon the estimated future traffic requirements, that is, the ultimate right-of-way will consist of a sufficient number of 10-ft. traffic lanes to carry the future traffic. The maximum width of right-of-way is 120 ft. and the minimum 60 ft. A 120-ft. highway will be used in instances where there is a double line of street railway tracks. These tracks will be located in the center of the highway, a 30-ft. width being provided for this purpose. On either side of the railway tracks the roadway will consist of 30 ft., or three traffic lanes in either direction. One can be used for parking, one for slow moving vehicles and one for fast moving vehicles, and the remaining area of 30 ft. or 15 ft. on either side, will be used for sidewalk purposes.

The 60-ft. right-of-way is intended to take care of a 40-ft. pavement, consisting of four 10-ft. traffic lanes, two in either direction, and 10-ft. sidewalks.

The other highway widths are planned on the same basis, that is, to provide sufficient 10-ft. traffic lanes to take care of the estimated future traffic. This traffic for right-of-way purposes is not the traffic 10 or 20 years hence, but 50 or 100 years hence.

There is a feeling that in many instances the traffic congestion on some of our highways can better be served by providing parallel routes for trucking. Such parallel routes, however, will only be between the large centers of population that are not too widely separated to justify from an economic standpoint, this method of transportation.

The strengthening and widening of pavements is the State Highway problem of the future and one in which the expenditure of enormous sums of money will be involved.

Now is the time to make intensive studies and investigations with a view to formulating principles and methods so that the future traffic will be adequately provided for and the highway expenditures controlled by cool, impartial and unbiased judgment based on the economics in each instance.

MODERN STREET LIGHTING

By F. H. Winkley, General Electric Co., Schenectady, N. Y.

(Presented at the 1925 meeting of the American Society for Municipal Improvements.)

Various phases of engineering enter into the construction of a modern street or thoroughfare. The engineer who specializes in street surfacing is primarily interested in the sub-structure and the covering; the sanitary engineer in the sewer system that underlies it; the city planning engineer in its dimensions, in its ornamental features and in its utility as part of a general scheme of facilitating travel; the illuminating engineer in its lighting, and so on.

Each is particularly interested in the phase that is related to his own field. He judges the street by whether the pavement is well constructed, whether it is equipped with proper sewers, whether it meets traffic conditions, or whether it is well lighted, as the case may be. He is apt to overlook the fact that the real basis of judgment is whether all these factors have been satisfactorily handled. The street is a good or bad street, from a construction standpoint, in proportion to the extent to which each of these items is good or bad. Moreover, this is the basis on which, to a large extent, the public will render its judgment.

Hence every engineer concerned with street construction should be interested in each of these factors, and should do what he can to see that satisfactory work is done in each respect. And street lighting should have a conspicuous place in this. Upon it depends the safety and comfort of traffic over it by night, the security and comfort of those who live or have places of business on it, and the safety of their property.

Modern street lighting is the result of constant progress and has reached a high state of efficiency. In its beginning the illumination of thoroughfares might well have been termed interrupted darkness. That was when the old open arc lamp was located at street intersections and simply acted as a marker.

In all probability it was sufficient when Old Dobbin was the prime mover in the vehicular world, but during the last 20 years urban transportation conditions have changed very materially. The fact that there are something more than 17 million automobiles in the United States has necessitated many changes in the width of streets in the paving, and also in the illumination of thoroughfares. Systems of first and second class business streets, boulevards, residential streets and highways have been worked out by city planning commissions; and illuminating engineers, with the co-operation of the architects, have designed lighting equipment suitable for these various types of thoroughfares.

The appalling number of traffic accidents makes better street lighting a civic necessity of first importance. In 1923, 22,600 persons were killed, 678,000 were injured, and $600,000,000 of economic loss was incurred, in traffic accidents. Statistics indicate that poor illumination was responsible for more than 17 per cent of the accidents that occurred at night.

The protection against accidents that proper lighting provides has not been equitably distributed. There has been a tendency to illuminate adequately our principal business streets and to neglect the secondary business and the residential streets and the boulevards. This has been, and still is where it is followed, a poor policy. It is a policy that is being changed by progressive cities, however.

There has been a similarly unwise and

unjustified division of the tax dollar. Analysis shows that hardly three cents of it is expended for street lighting—an amount which, when the importance of thoroughfare illumination is given the consideration to which it is entitled, is altogether too small. The average sum per capita expended by municipalities in the United States for street lighting is less than one dollar. It should be about three dollars.

The illumination of our highways is a subject that should be given consideration. A few years ago illuminating engineers were asked by automobile club officials to design automobile headlights which would entirely eliminate the objectionable glare which casues so many traffic accidents. The glare was eliminated, but the headlight is ineffective. In order to have the proper pick-up distance on an automobile headlight, a certain amount of glare is absolutely necessary; and as long as this can not be eliminated, the illumination of the highways is the only offset. Highway lighting units which overcome this glare have therefore been devised, and they represent the real solution of the problem. Highway lighting is an improvement that, so far as the main routes of travel are concerned, must come in the near future—is coming now, as a matter of fact, in various sections of the country.

Floodlighting is another subject in which the municipal engineer should be interested. Because of its various utilitarian and spectacular applications, it plays a most important part in the field of outdoor lighting. For example, an electrical fountain in a park presents a beautiful spectacle at night. The streams of water and the spray are illuminated with colored floodlighting projectors, and various combinations of water pressure and color changes produces fascinating kaleidoscopic effects. The flood lighting of public buildings, monuments, playgrounds, etc., promotes civic pride, adds to their appearance and tends to create a cheerful atmosphere after Old Sol has done his day's work. Decorative lighting is not merely an effective feature in connection with municipal Christmas trees, pageants and other undertakings of the kind, but is an almost indispensable adjunct to them.

May I repeat the plea that street lighting be given the consideration by all engineers to which its importance entitles it? Let me add that to all engineers it has a double interest—an interest from the standopint of good citizenship as well as from a professional standpoint. The proper illumination of our streets and highways is something in which we must inevitably have a concern, not merely because it represents an important branch of our profession, but because the safety, comfort and convenience of all citizens depends on it. Good lighting is safety insurance of a very practical kind.

SPECIAL USES OF ASPHALT DISTRIBUTORS IN ROAD MAINTENANCE

By William E. Worcester, Kinney Mfg. Co., Boston, Mass.

(Paper read at Fourth Asphalt Paving Conference at Detroit, Mich., Oct. 21-23, 1925.)

Let's start out and define an asphalt distributor, since in many places any truck or trailer with a tank and manifold that may be used to transport liquid material to the road, is considered a distributor. As a matter of fact, however, transporting the material to the road while necessary, is incidental, and may be accomplished by various satisfactory methods, but a distributor is a device for measuring bituminous materials on to the road with temperature of material and quantities under absolute control, and should have the following characteristics:

1. A distributor to be used for all the various types of asphalt maintenance should always have a heating system, and such a machine should always have means for circulating or agitating the asphalt while heating or it will be burned and coked in some spots before other parts of the material are hot enough to apply.

The machine with which I am most familiar has an oil burning heating system and circulates the asphalt from one end of the tank to the other while heating, by means of a pump.

2. The nozzles should be arranged so that the material strikes the road with sufficient pressure to drive off fine loose dust particles and to spray the material uniformly without streaks or bare spots, but they should, under no circumstances, atomize the material. Best results either for hot or cold materials are obtained by a sheet of material striking the road surface under pressure.

3. There should be mechanical relation between the speed of the vehicle and the output of the machine, so that the quantity applied and the yardage covered are in a fixed ratio without depending on the operator's skill to adjust the machine while in motion. It should be possible to set the machine for any desired quanity.

When you consider that practically every distributor now made in the United States has an output of from 200 to 350 gals. per minute, it is easy to see that the possibilities are in favor of extremely bad results if this problem is left to the operator.

4. A distributor should be provided with lateral movement to the spray bar manifold to aid the operators in lining up their applications to prevent either streaks between or lapping of the applications in the middle of the road.

5. A thermometer should be furnished and so located in the tank that a true reading can be obtained; since the temperature limits at which various materials should be handled are rather close.

The above are fundamentals; many other refinements are highly desirable, such as connections for a hand patching hose, arrangements to make the machine self-loading from tank cars or storage; and equipment that is readily demountable so that the truck chassis may be used for other work.

A machine such as described above will successfully handle the following operations:

1. Apply dust laying and cold oils to dirt, gravel and macadam streets and roads.

2. Apply thin paint coats to concrete or other bases prior to laying asphaltic concrete, Filbertene or similar tops.

3. Apply such asphalt cut back materials for surface treatments as Pennsylvania State Highway "C," Ohio "Cold Oil," or Maryland "Liquid Asphalt" that may require twenty or thirty degrees heat but may be pumped cold from tank cars, thus avoiding the necessity of steaming the cars.

4. Apply low penetration asphalts for resurfacing of brick streets with asphalt tops.

5. Apply grades required for penetration construction, hot surface treatments and sealing old hot mix pavements.

6. Patch holes (hot patch method) and apply material along park drives and walks, using hand hose where manifold is impractical.

For the above work a successful distributor should have a capacity range per square yard from 1-10 to 2 gals.

Besides the more usual uses of distributors, the State Highway Department of Virginia has found it highly profitable to use their distributors during the colder months when they were not in regular use, to transport cold patch material for their maintenance crews.

Formerly, this material was purchased in barrels or metal drums which were rented from the material companies, or the barrels purchased with a refund when returned in good condition. By purchasing in tank cars a considerable saving was made in initial cost. Drums were purchased outright and distributed along the roads, the material being pumped into the distributor with its own pump, and then the drums filled on the road from the machine, saving freight and cartage on the drums and earning good rental on equipment which would otherwise be idle.

A Florida contractor with a considerable amount of asphalt filler to apply to brick streets, found his distributor would handle brick filler at high temperature, applying it through the patching nozzle at a great saving in costs over the usual hand poured system.

Distributors are frequently used to unload tank cars to storage. The city of Boston, for many years, used theirs as an auxiliary to the fire department for dump fires, filling it with water, however, instead of asphalt.

The importance of intelligent operators is frequently sadly overlooked. The operators should be more intelligent than the ordinary unskilled laborer. While most of his work is simple, from a mechanical standpoint, the value of the materials handled is considerable, and if a mess is made with the application of bitumen, the preparation of the road and covering material is at the same time largely wasted, so that careless operation can easily involve the loss of several hundred dollars in three or four minutes. Coked material will not bind the road, nor will too cold material. If too much material is applied the road will roll, if too little, it will ravel. The operator must do the thinking since the machine can not.

Since there is so much possibility of faulty construction of penetration macadam streets, and surface treatment, due to the use of improperly designed distributors, I would like to see this association use its influence to have inserted in state,

county and city specifications at least the five fundamentals first mentioned, as requirements for an "approved distributor" and I believe the results of such a specification would be a much larger proportion of successful work and a greater use of asphalt and asphaltic oils.

CALIFORNIA MOTOR REVENUES LESS THAN ESTIMATED

(Editor's Note: The following statement is published to suggest to those responsible for highway financing measures that it is easily possible to over-estimate revenue from motor vehicle gasoline taxes and license fees.)

Motor vehicle registrations for the year 1925 in California and the State Highway Commission's income from gasoline tax funds are below any predictions made during the recent legislative session. They even fall slightly below the estimates of the Highway Investigating Committee.

This announcement is made by State Highway Engineer R. M. Morton. The annual program of the State Highway Commission must be based on predictions of the amount to be received; therefore, the highway department closely studies all the returns.

Reviewing the situation as developed by the apportionments made by the State Controller and the Motor Vehicle Department, Mr. Morton recently issued the following statement:

"During the session of the Legislature last spring numerous conflicting predictions were made as to the amount of money that would be available under present statutes for the maintenance and reconstruction of state highways. The money for this work is supplied by motor vehicle registration fees and gasoline tax funds, one-half of the net returns of which are apportioned to the California Highway Commission.

"All apportionments for the year 1925 have now been made, and a comparison of the actual returns with estimates of a year ago is possible.

Gasoline Tax Income

"The Highway Commission has received as its share of the gasoline tax fund during 1925 the sum of $6,868,945.94. The Highway Investigating Committee estimated that the income this year from this source would be $7,100,000. Estimates of the oil companies and others were much higher.

"The Highway Investigating Committee estimated an increase of 17.11 per cent over the 1924 gasoline tax returns The actual increase was 13.29 per cent.

Motor Vehicle License Fees

"The situation regarding vehicle license fees is as follows:

"The total registration for 1924 was 1,350,429. The Highway Investigating Committee estimated that this number would be increased to 1,490,000 by the end of 1925. Other estimators placed the 1925 registration as high as 1,580,000 vehicles. There still remain a few weeks of the year 1925, but the Motor Vehicle Department announces that the 1925 registration, based on eleven months, on account of the changing of the registration year to end December 31st, will be about 1,480,000 vehicles, an increase of only 9.6 per cent over 1924. The Highway Investigating Committee, in its report to the Governor, estimated an increase of 10.34 per cent.

No further apportionment of fees will be made during the present calendar year. The total estimated to be received by the Highway Commission from the motor vehicle fund from 1925 registrations is $3,419,525. This is an increase in the state's share over 1924 of $339,866.18, or 11.04 per cent. The actual increase is considerably under all estimates made last year and indicates that the former rapid increase in motor vehicle registration in California is slowing down.

"The special transportation tax on truck and stage lines, the estimated return from which was placed by some at $600,000 annually, is tied up in court litigation and has provided no income.

"It is predicted by the Motor Vehicle Department that the 1926 income from license fees will be reduced by $500,000 gross, as a result of the lowering of registration fees on Ford cars with cargo bodies. This will mean that, in 1926, the Highway Department's income from motor vehicle registrations will probably not exceed the 1925 income.

Must Take Conservative View

"Although the gasoline tax and motor vehicle registration fees will increase, the highway engineer takes a conservative view of the amount of increase. He believes that no better estimates are available, as a guide to future revenues, than those made by the Highway Investigating

Committee in its report on the state highway situation, filed with the Governor in February, 1925.

"These estimates were, last spring, declared to be ridiculously low by those opposed to increased revenue for highways, but the amounts realized in 1925 for state highway maintenance and reconstruction are even less than the most conservative estimates available at that time."

SURFACE TREATMENT OF GRAVEL ROADS WITH ASPHALTIC OILS

By J. T. Bullen, Parish Engineer, Caddo Parish, Louisiana.

(Paper presented the Fourth Asphalt Paving Conference, at Detroit, Mich., Oct. 21-23, 1925.)

The engineer's problem today is not alone to design new pavements but to conserve the investments previously made in the ordinary gravel and macadam roads.

When I say gravel I mean a sand clay gravel composed of from 50 to 70% water worn pebbles combined with 30 to 50% of clay and sand, with the sand predominating to some extent. The sand should have some coarse grains and the clay have good binding qualities.

Climatic Conditions

In Caddo Parish, Louisiana, we have been building gravel and macadam roads since 1912. Our seasons are nine months summer and three months of winter. Average winter temperature is about 45° and average summer temperature is 83°, though the temperature frequently goes down to 16° in winter and stays above 90° for days at a time in summer and frequently stays around 95° to 100°. We have little or no snow or ice and frost does not penetrate to any depth. One-fourth of our roads lie in the flat bottom lands of the Red River of the south and three-fourths lie in the hills with occasional grades up to 8 and 10%. Our annual rainfall is about 54 inches, and sometimes 16 or 18 ins. in a month.

I surmise that many of you look on Louisiana as a dismal swamp alive with alligators, but such is far from the truth, as you may know when I refer to 10% grades. I mention these climatic and topographical conditions because such details have a bearing on any kind of road work. We have 47 miles of paved roads and approximately 15 miles of macadam and 120 miles of gravel roads.

Notwithstanding our 54 ins. rainfall, we frequently have long dry spells lasting for many weeks and even months. Such dry spells are sometimes followed by torrential rains, 3 ins., 4 ins., or even 6 or 8 ins. in 24 hours. In the dry spells the clay gravel travels and gets exceedingly dusty and on steep grades a torrential rain will easily form gulleys in the surface.

Add to such difficulties a traffic increasing at the rate of 100% annually and it becomes clear that an untreated gravel will not sustain the traffic for long, nor be an economical surfacing. We realized this in 1913 and, so far as I know, Caddo Parish was the first locality to try heavy asphaltic oil as a surface treatment for clay gravel roads. In August, 1913, the first oil was applied. All of the mileage to be treated had been completed from six months to a year and was pretty thoroughly consolidated and smoothed out.

Method of Application

First the gravel was very thoroughly swept with a rotary steel broom which generally removed from ⅛ to ⅜ in. of fine pebbles, sand and clay and deposited it in windrows on the shoulders of the road. Hand brooms of a type used on city streets were also used to clean any part of surface not thoroughly cleaned by the rotary sweeper. Oil was then applied at the rate of 1/3 to ½ gal. per sq. yd. at a temperature of 225° to 300°F. and was immediately covered with the sweepings previously swept from the surface. Our first oil contained about 85% to 89% bitumen and was obtained from California.

One-half of the road was treated at the time the other being left open for traffic and though 18 or 20 men followed closely behind the distributors, covering the oil with the sweeping, some vehicles would get on it and pull strips of oil from the surface before we could get it covered with the sweepings. The distributor's nozzles, one or more, would occasionally become clogged and cause skips, all of which had to be touched up a few weeks later, but in 30 to 60 days' time travel had ironed out the oil into an almost perfect surface, resembling an asphaltic concrete pavement.

The first oiling was done in August and in September we had 16 ins. of rain, which did not damage the surface in the least. It continued in good surface dur-

ing the winter of 1913 and spring of 1914. At the end of 12 months, with the exception of a few breaks, it was still in good condition and an auto traveling 50 miles an hour would raise scarcely any dust. In about fifteen months the broken places in the surface began to show to a considerable extent and at each break in the oil a chuck hole was forming. To make a long story short, in 18 months the general surface was very rough and not nearly so easy riding as the untreated gravel road.

The freight on the oil made it expensive and the cost of distribution by contract seemed higher than we could afford.

A few years later we were able to procure the same class of asphaltic oil from Baton Rouge, La., at a lower price and with much lower freight rates and we began the oiling of the roads in a systematic way.

Bear in mind when I say oiling that I do not mean the usual coating of light cold oils which are frequently used as dust layers or even those oils slightly heavier which require several coats to form a surface. It has been my belief from the inception of this work that to quickly get the asphaltic surface on the gravel with the least labor, was the true objective.

The Oils Used

Consequently from the first we have used heavy asphaltic oil such as the grade known in the market as Standard Binder A or Texaco Macadam Binder. Generally we have used Binder A, the analysis of which is as follows:

STANDARD BINDER A

Spec. Gravity @ 77° F	996/1.010
Flash—Open Cup °F	390/400
Flash—Elliott °F	350/365
Spec. Viscosity @ 25° C (77° F)	No Flow
Spec. Viscosity @ 100° C (212° F)	34/37
Float Test @ 32° C (90° F)	360/390
Penetration 100-G 5 Sec. 77° F	.....
Loss @ 163° C (325° FO 5 hours	(1.0/3.0%
	(20 G
Penetration of Residue 25° C (77° F)	Too Soft
Float Test of Residue @ 50° C (122° F)	112/118
Penetration 200 G. 1 Min. (32° F)	.....
Penetration 50 G. 5 Sec. (115° F)	.....
Melting Point (Ring & Ball) °F	.....
Asphalt to 100 Penetration	85/90%
Soluble Carbon Bisulphide	99.9%
Soluble 86° Naptha	84/86%
Ductility	.....
Fixed Carbon	12/14%

The consistency of this asphalt is such that it takes considerable heat to get it out of the tank cars, which is accomplished by connecting a steam line to the coils provided in such cars and this steam is applied for about 10 or 12 hours, or until the asphalt is hot enough to flow by gravity into our concrete storage tanks or be pumped into our distributors.

Our concrete oil reservoir has steam coils in the lower part into which we can turn live steam when it is desired to withdraw it to distributors.

Workmanship

One thing I would like to stress at this point is in regard to the personal element entering into the work.

It takes an observant, conscientious and painstaking foreman to get the best results and a complete record of each tank distributed should be kept. In that record should be noted the comparative character of cover (fineness or coarseness), how many days of dry weather preceding the treatment, and every condition of weather, surface or oil which might have an effect on final results. With such a record the failures should gradually be eliminated.

It is quite easy to apply too much oil and without careful checking of surface covered, you will not always know from a foreman's report whether 1/3 or ½ gal. per sq. yd. has actually been used.

Gravel or macadam roads with steep grades treated with heavy asphaltic oils are insured against longitudinal or transverse gullies which would be caused by heavy rains on untreated surfaces.

In a treatment apparently so simple the details are quite important.

The details necessary for success are: First, a surfacing material bound so thoroughly together that when it is swept, the gravel or stone remains in place, and only a small part of the binder can be swept out, leaving slight crevices for the oil to get its grip.

A gravel with binder too sandy is almost sure to fail, because you cannot sweep it clean without loosening the surface.

It is essential to get the surface well consolidated by traffic before applying oil, so that the gravel will not ravel under the oil.

Apply only sufficient oil to completely cover the surface; the first application generally requiring between 1/3 and ½ gal. per sq. yd. Later applications generally require ¼ gal. per sq. yd.

It would probably give better results if the oil could be left uncovered for from 12 to 24 hours. With us we have few roads over which to detour traffic, consequently we cover the oil immediately after distributing it. A gang of men follows the distributor casting back on the road the fine gravel, the sand and clay previously swept from its surface.

We have found these sweepings make an excellent cover, containing as it does, particles from ¾ ins. down to fine clay. In casting this material on the oil, it is well to cast it in line parallel with center line and not transversely. The cover must be in quantity sufficient to prevent vehicles from picking up the oil.

After the first application there will be no sweepings, therefore cover will have to be hauled in for subsequent treatments. We sometimes ship in a coarse sand for this purpose and sometimes use a fine pea gravel or broken stone with dust left in. The stone is probably to be preferred, though we find a sand graded from fine to coarse serves excellently for the purpose.

I have even seen the oil covered with stiff red clay and, to my surprise, it ironed out in good shape. The clay is not desirable for several reasons, one of which is, that it leaves no grit in the surface to reduce slipperiness.

As a matter of fact, we find that our oiled roads are not slippery; the cover composed of the sand and small pebbles or stones gives it a good, almost non-skid surface.

Repairing Breaks

In repairing the breaks in the oil, we use Standard Cold Patch or Texaco Cold Patch which costs about 16c per gal. in barrels. This we mix with small stones and allow it to cure for a few days so the volatile oils may escape, and this material is spread cold and tamped in place after cleaning out loose material from holes and painting holes with cold patch, or some other thin asphaltic oil.

Don't begin using oil on your roads unless you can, and will, afford to apply a renewing coat of say ¼ gal. per sq. yd. at intervals of 12 to 18 months and prepare to begin patrolling oiled roads as soon as oiled. The little breaks must be touched up with oil from hand pouring pots or with cold patch as soon as they appear.

I don't think there is any question of the economy of such a surfacing. We are compelled to use a soft marble for macadam roads—a material which under our traffic of 1,000 to 4,000 vehicles per day would wear into deep holes and ruts in two or three months unless protected by an oil mat.

With the oil surface, this same material does sustain the above mentioned traffic for years at a time, with practically no loss of material and no rutting. We have such macadam surfaces constructed over five years ago within 3½ miles of the Courthouse at Shreveport (a city of 75,000) and carrying heavy oil-field traffic, and they have been maintained in good surface for less than $500 per mile annually and with no additional rock.

Several coats of oil have been applied and sufficient oil has now been applied to cause some waviness in surface.

A little later we will have to scarify the surface lightly re-roll it and re-oil it.

The same statements apply to many miles of our clay gravel roads which are in excellent condition several years after first application of oil.

The Louisiana Highway Commission has been keeping a careful check of traffic on the state highways, and, in a recent issue of their monthly magazine, it is stated that the maintenance costs on untreated gravel roads amount to about $600 per mile annually and that notwithstanding this expense for maintenance, traffic is wearing away or winds and rains carrying away about 1 in. of gravel per year, estimated to cost $1,000 per mile per year, or a total cost of approximately $1,600 per mile per annum. With the oil surfacing, the $500 or less, per mile maintenance charge is the total annual cost, because the gravel cannot wear away, blow away or wash away.

Then consider for a moment the saving which oiling effects for the users of the road. Information from university tests and actual costs in several parts of this country indicate that the saving to automobile owners in gas, oil and tires effected by a paved surface in comparison with an ordinary gravel surface is at least 1½ cents per mile and even 2 cents per mile. I am convinced that, as compared with a loose gravel surface such as we have in Louisiana during our long dry spells, the saving effected by oil sur-

facing must be at least 2 cents per mile.

As a matter of fact, one of our transfer companies runs about 50 buses a day over different routes out of the city of Shreveport. Some of these buses are confined to roads almost exclusively surfaced with oil, while others are kept on gravel roads unsurfaced, and although these unsurfaced gravel roads are machined almost daily, they have much loose gravel. In looking over the statement of maintenance costs on the equipment of this company which had been worked out in the cost per mile, I was interested in the fact developed by those costs, that the buses operating over the untreated gravel roads were costing about 2 cents more than those operating over the paved and the oil surfaced roads. And the difference in cost to the Transfer Company on seven buses operated over the untreated road amounted to $6,000 more than for the same mileage in a year over the oil surfaced roads.

This, mind you, is but the loss of one company on seven buses. What must be the loss to the whole traffic?

Of course you must add to these savings by the use of oil, the very great saving to the people in the abatement of the dust nuisance; the increased pleasure in the use of the road; the decided factor of safety in the prevention of collisions caused by dust and the enhanced value of property along the road because of the abatement of the dust.

Cost

I think I have made out a case for oil surfacing; what then is the cost?

We keep careful cost accounts on all our work, and for five or six years we find that there is but little variance in the cost. It runs from 5 to 8 cts. per sq. yd. for first treatment, or $500 to $800 per mile on an 18-ft. surface. These costs include $30 per day for use of oiler, also the cost of sweepers, labor, foremen, trucks and covering material. The cost varies depending on length of haul, length of the stretch to be oiled and some other variable factors.

We sometimes take the oil over 40 miles from town and apply it at not to exceed 8c per sq. yd.

If we could continue this work over any regular period, using the equipment each day, we could reduce these costs considerably, but we only oil, or re-oil, a mile, or perhaps 2 or 3 miles in one job, and then move perhaps to a point 50 or 60 miles away, where the next oiling is necessary.

WIDENING AND THICKENING CALIFORNIA STATE HIGHWAYS

By R. M. Morton, State Highway Engineer, Sacramento, Calif.

(Editor's note:—This timely article is from a recent number of "California Highways.")

Reconstruction of already improved highways, since the enactment of special revenue measures in 1923, has, in California, assumed a position of high importance in the work of the State Highway Department. By legislative action at the 1923 session, the revenue available for maintenance and widening was doubled when the gasoline tax of 2 cts. per gal. and the normal registration fee were substituted for the former horse-power tax.

The Highway Department this year will receive as its share from these sources (one-half the net collections) considerably over $9,000,000. The law requires that this fund be expended for maintenance, repairs, widening and reconstruction of state highways. About 60 per cent is available for major widening and reconstruction. The remainder is necessary for general maintenance. (Maintenance funds will have to be increased somewhat next year when all traversable routes will come under state jurisdiction.)

Several Plans Followed

The Highway Department follows several plans in the widening and reconstruction of pavements. The type to be used on a specific project is chosen after a study of the physical features. Availability of materials, condition and width of pavement, alignment, grades and soil conditions enter into the choice of type. The present and probable future traffic are considered in planning the width.

Most of the original pavements built by the state are of Portland cement concrete, 15 ft. in width and from 4 to 5 ins. in thickness. Many miles of county-built pavements of varying types and widths, generally of light construction, have been incorporated into the state's system.

Widening work includes concrete shoulders built flush with the existing pavement; raised concrete shoulders and asphalt concrete surfacing; asphalt concrete shoulders and surfacing for the full width and second story concrete shoulders and resurfacing. In locations of light traffic and where suitable materials

are available, oiled macadam shoulders are sometimes built.

Future Program is Large

About 600 miles of state highway pavements have been already widened, of a total of about 2,400 miles. At least 1,500 miles more will require widening as fast as funds are available.

The original width of pavement constructed from 5 to 15 years ago was 15 ft. This width becomes overstressed with a traffic in excess of 1,000 vehicles per day. Corner breaks and settlement of the edges occur, and it is impossible to keep shoulders flush with the pavement. Our traffic counts indicate that a 20-ft. pavement readily handles a traffic up to 6,000 vehicles per day, and is not overstressed until 10,000 vehicles per day is reached. When the traffic exceeds that amount, additional widening or a second road is considered necessary. Often, however, this heavier traffic occurs in suburban districts where the building of a full width street, with curbs and gutters, is required, and a large portion of the cost is defrayed by the adjacent property owners. The width generally adopted for the average pavement reconstruction is 20 ft.

Where the existing pavement is in good condition, cement concrete shoulders 2½ ft. wide and 7 ins. in thickness are placed at either side of the existing 15-ft. slab. In preparing subbase for this type of widening, the soil is excavated for several inches beneath the edge of the existing pavement to form a joint and give added strength to the edge of the old pavement. Most work of this nature contemplates future surfacing over the entire width of the pavement.

It is usually required that only one side of the highway be worked on at a time in order that there may be no interruption to traffic. During 1924 California completed about 26 miles of this type of widening at an average cost of $10,493 per mile. This also included the widening of grade from 21 ft. or 24 ft. to 30 ft. and the extension of culverts.

Combination Proves Successful

A type of widening and thickening which has proven successful is a combination of concrete shoulders and asphalt concrete wearing surface. The shoulder is laid 7 or 8 ins. thick at either side of the existing concrete slab and raised about 3 ins. above it. An asphalt surface not less than 2 ins. in thickness is placed over the old pavement and extends into an offset built into the new concrete shoulder, thus making a perfect seal and water-tight joint.

This type of surfacing and widening is placed where the existing concrete base is still in fairly good condition but where it may be predicted that the end of its economic life is fast approaching. About 180 miles of concrete highways have been widened and thickened by this method at an average cost of $22,400 per mile.

A variation of this type is the construction of asphalt shoulders in stead of concrete shoulders. Under this method a base 2½ ft. wide and 4 to 5 ins. in thickness of asphalt concrete is placed at the side. This is followed with a leveling course of asphalt, and a wearing surface completes the job. The cost of this type of work on a typical project, which includes rather heavy grading quantities and the lengthening of many drainage structures, was approximately $30,000 per mile. For the paving alone, the cost is usually little less than the cost of an installation of concrete shoulders and asphalt center.

This plan has been successfully used on widening oiled macadam highways. The first step usually consists in placing a macadam foundation at the side of the existing oiled macadam highway and permitting it to remain open to traffic over a season. This is followed by the placing of a leveling course over the old pavement and the new shoulders, which is followed with a wearing surface of the same material. One typical project of this nature in 1924 cost about $24,000 per mile for an 8½-mile section.

Oiled macadam roads have been widened, thickened and leveled with asphalt concrete in varying width. The thickness of the new surfacing usually varies from 1½ ins. to 3 ins. The aim of such work is to improve riding qualities of the surface and utilize the old base as a foundation. Such work will average $10,000 per mile in cost.

"Second Story" Concrete

The most costly type of reconstruction is the second story concrete. This consists of a slab of concrete usually 20 ft. in width placed on and overlappng the edges of the original 15-ft. pavement. For this work the standard thickness is a minimum of 5 ins. in the center, increasing to 7 ins. at the edge of the old slab and 9 ins. at the outside edge. Special attention is paid to the subbase under the overlapping edge of the new pavement, and the extensions beyond the edge of the old pavement are reinforced

with steel. Transverse and longitudinal joints are placed.

This type of resurfacing is usually chosen where the old pavement is broken and in poor condition, having reached the end of its economic life. About 78 miles of this type of reconstruction have already been installed at an average cost of about $31,720 per mile. including widening the grade and lengthening drainage structures.

Heavy Pavements Needed for Traffic

California has widened state highways to widths of 20, 24, 27, 30, 40 and 56 ft. On one particular job a 24-ft. asphalt surface on a concrete base was widened to 40 ft. by means of 8-ft. concrete shoulders on both sides, 8 ins. in thickness with 10-in. edges. The old asphalt center was dressed up with a new asphalt concrete wearing surface. On this with highway separated into traffic lanes by the appearance of the materials, the slow moving commercial traffic tends to concentrate on the shoulders at the end, leaving the center free for faster traffic.

The most costly completed section of state highway reconstruction was completed in 1924 near Los Angeles, with the co-operation of the county and an improvement district. The old 20-ft. oiled macadam roadway was replaced with a street 56 ft. wide between curbs. A subbase of decomposed granite was first placed, then a 7-in. Portland cement concrete base finished with a 2-in. asphalt concrete surfacing. This government cost approximately $150,000 per mile.

HIGHWAY POLICE AND HIGHWAY SAFETY DEVICES

By John A. MacDonald, State Highway Commissioner, Hartford, Conn.

(Paper read at 1925 meeting of American Association of State Highway Officials.)

Highway engineers have had many problems thrust upon them due to the increasing number and to the ever-increasing speed and weight of motor vehicles.

As they increased in number and operating speeds increased, there came a steady increase in highway accidents resulting in loss of life and damage to property to such an extent that the public generally, as well as the engineers, realized that the condition had to be relieved.

To the engineer not yet provided with sufficient information relative to foundations and surfaces, nor with sufficient means to provide a suitable number of lanes for highway transport, nor with sufficient information as to the limits of increases in speed and weight, came the responsibility of providing safety as well as strength; and, as is usually the case with public questions, the cheapest possible method was resorted to—that of restriction which increased the problem and delayed and increased the cost of solution.

The various legislatures passed laws providing for a restricted use of the highway, a retstriction on speed, and restricted the various uses which had heretofore been enjoyed. The engineer devised signs and schemes for the slowing down of traffic at the more dangerous locations.

Neither of these were effective for any length of time. The laws were ineffective as passed, due to their lack of enforcement. The signs served their purpose for a short time, but readily created congestion and accidents.

To correct one of these conditions, highway police and patrols were provided to enforce the various rules as laid down. To correct the other, many safety devices were provided.

It is not my intention to devote any time to the question of the necessity for highway police, as I come from one of the New England states where it is a foregone conclusion that a law is only as good as its enforcement. These organizations will come either by the creation of a new force or the expanding of an old one when a persistent demand is made by the public for enforcement against the willful offender. Nor is it my intention to devote any time to the method of organization, as this is a matter which naturally must be handled by each political sub-division in its own way, due to the many local policies and conditions, and will, no doubt, take the usual form of all legislation progressing through its various stages.

It is impossible to organize a force of this kind perfect, but by progressive legislature, it may approximate that condition.

However, after having passed through the organization of one highway patrol and being intimately connected with the reorganization of a police department, and having an opportunity to study each in actual operation, then seeing both combined, and having an opportunity to study the results—and considering the type of work specifically laid out for any highway police organization—it is my

opinion that it should be entirely separate from the enforcement of or the work connected with any other police matters.

Duties of Highway Patrol

The minimum duties of any highway patrol should be:

1. The examination of operators for licenses, and the examination of the safety features of the vehicles themselves.
2. The prevention of damage or unwarranted use of the highway.
3. Enforcement of the motor vehicle laws or code.
4. Supervision of the movement of traffic.
5. The prevention and investigation of accidents.

It is very important that officers connected with organizations which have to do with highway traffic be educated to an entirely different viewpoint from the ordinary policeman, and should become specialists along the lines of their respective duties, as they deal not with the ordinary criminal class as a rule but with an entirely different class of people and for an entirely different purpose. No matter how reasonable such a force may be in its enforcement, it cannot help but produce an actual revenue in excess of expenditure. It is not to be assumed by this that at any time will there be sufficient means provided which will enable highway police to cover every point where their presence seems necessary. Consequently, the foundation of any highway police patrol must be an information and statistical bureau to produce the required statistics and the information as to where they should concentrate their efforts.

The only scheme yet devised that I know of requires each accident upon the highway to be reported to a central agency, there to be analyzed as to cause and locality, and the information thus obtained presented back in simple form to the officer for his guidance.

In addition to this, it is necessary that he know accurately the kind, the density, the peak lead, etc., of traffic on the highways to properly guage his information, and a traffic census is as important to him almost as it is to the highway designer. A traffic census gives an officer the weight to measure his statistics and shows his relative conditions and where his presence is needed most. With this fundamental knowledge, his every movement is towards the prevention of accidents without the loss of efficiency, and what he lacks in numbers is made up by his efficiency.

The efficiency of any organization of this kind is not to be assumed as is the ordinary police department by the number of arrests it makes or the number of convictions it assures, or by the amount of revenue it produces, but by the reduction in the number of accidents and the condition of the traffic which it directs.

It must study the causes of accidents, and if the cause is one for education, propaganda and orders must be sent forth. If it is one for enforcement, the proper orders must be issued, and a uniform enforcement policy immediately instituted.

A force of this kind should be directed principally against the worst condition until it is eradicated or corrected, gradually stepping down the ladder until a distinct improvement in accidents and traffic is noticed.

Enforcement must always be standard and not spasmodic. The public must necessarily be taught and constantly reminded that at certain places they can do certain things with safety, and at certain other places, it is impossible.

This force must be properly equipped and the personnel adequate. By this, I do not mean numbers, but intelligence. Above all things, it must have the confidence of the public and the support of the courts behind it. To gain public confidence and the support of the courts, its enforcement must be reasonable, equal against every person and just. Its officers must be gentlemen, hard-working, sober, industrious, helpful and fair. It must operate within a reasonable expenditure of money, and it must uphold the dignity of the political sub-division that it represents.

Now, often times, due to conditions, an officer is not necessary at all times, so we avail ourselves of his substitute—the highway safety device, and, in so far as I am able to define it, it is a device which will either give direction or warning to pedestrians or traffic—which definition would include reflectors, warning signs, guard rails, beacons, fences, light houses, silent policemen, lights, buttons, symbols on pavements, etc., and so on. There are many forms and kinds, and I believe that you are as familiar with them as I am. It is with their use and misuse principally that I am concerned.

The time probably will never come when we will have a sufficient number of lanes for traffic so that a certain amount of restriction will not be necessary to

properly regulate and move traffic, and we will necessarily have to depend on some devices, but no safety device should ever be used that has for its objective the slowing down of traffic.

It is impossible now for us to build highways fast enough to even keep abreast of the motor vehicles that are being put into use, and if we are to make our highways adequate to carry the traffic, we must raise the efficiency of the highway, and the only way that I see that this can be done is to increase the speed on the highways, bearing in mind at the same time that the accident rate must not increase but decrease.

Many of us find ourselves maintaining roads (I am not going to call them highways) on locations of old Indian trails, winding in and out through hills and valleys, as the Indians walked, and sometimes I am inclined to think staggered instead of walked. Even these highways might be used with safety if the driver of a vehicle would operate his vehicle in such a manner as to be capable of stopping it within the range of his vision, but the average motorist is rather indifferent to safety and demands convenience with or without safety, and convenience to him means not congestion but speed.

This rule would, no doubt, be impossible of enforcement for the reason that it would immediately create congestion following its introduction, and so we proceed to place what we are pleased to call warnings at these dangerous locations for his safety.

It has always been a question in my mind whether the net result of any safety device is not only to increase the speed. I know from experience that we gain little on the safety side of traffic by improving the sight line, as the speed generally increases to such an extent as to nullify the additional sight line.

Any highway safety device has for its purpose to give the driver of a motor vehicle a picture of what he is to encounter ahead of him so that his speed will not be checked and too much strain will not be put upon his attention, and the picture that you desire him to get may or may not photograph on his mind correctly and so allow him correctly to judge his position. If your device happens to be good enough to attract his attention sufficiently, he goes on his way; if not, unless he is lucky—especially if two or three other conditions are present—an accident.

Many men have many minds, and one driver in Ohio getting the proper picture from the Ohio standard may take a notion to drive into Virginia and not receive from the Virginia standard the proper picture, so that if we can have one standard, it will help.

Up until the present time many systems of warning signs have been used without regard for uniformity. Recently, a Board appointed by the Secretary of Agriculture has put forth a very complete, common sense and simple system of uniform signs which I understand is to be adopted on all Federal Aid Roads. It would seem a great step in the future if these signs could be adopted for all highways, whether Federal, State, County or Township, so that a uniform system of highway markings might be thus obtained; and, after the uniform system, if we could find some way to have a uniformity of minds to register on, the problem would seem solved.

There is also a standard for colors proposed by the Sectional Committee of the American Engineering Standards Society which, while probably not perfect, should be used in so far as possible.

Up to the present, apparently not enough attention has been paid to the placement of devices. Some are very efficient in fine weather or in the daylight but very poorly placed after dark. It would seem that each should be located at a time when conditions were worst.

It is very important that devices be uniformly placed along the road so that operators of motor vehicles will know where to expect to find them. It is also important, due to the development of motor vehicle headlights, that signs be low enough so as to come within the rays of head-lights at night, and good practice would recommend that all direction and warning signs be located at night with automobile head-lamps for guides and if possible in stormy weather.

During fair weather and when the highway is clean, and when the headlights are properly focused, symbols painted upon the pavements have been very efficient; but if there is snow or ice on the highway, or the highway is dirty or a temporary type of pavement is used, these signs are of no value, and in many places they have become so numerous that the public has generally ignored them.

The Most Severe Test

The worst possible condition I can think of is the motor vehicle operator who cannot read, is color blind and is operating a car against glaring headlights on a strange road after dark and in a snow

storm. That is my test for a good device; and if it can give the operator of the vehicle the proper information at that time, then I would not hesitate to use it.

Too many devices destroy the value of important devices, and the tendencey has always been to place more warning devices than are necessary, and fewer directional.

The grade crossing has been one of the points that has attracted many inventors and originators of safety devices. In so far as I know, no one system or any combination of them has been effective as yet. To my mind, they all have for their objective the closing down or stopping of traffic which is again the old restrictive idea.

Most of the devices which I have noticed at grade-crossings call for a stop. It would seem to me that a cautionary sign at this point would serve the purpose as well and still allow the operator of the vehicle to use his own judgment.

Any highway safety device should be positive at all times. It should say exactly what is to be insisted upon—no more and no less. Devices which do not follow this rule and which say what they do not mean really cheapen the effect of other necessary devices.

To my mind, elimination is the only safety device which apparently is effective at grade crossings. It will, of course, never be possible to eliminate all the dangerous conditions, but when it is realized that within the next 30 years, we must expect three and one-half times the present day traffic, it would seem that we should hesitate in the matter of placing highway safety devices and realize that the fewer of these that we use, the easier our future problems will be to solve.

If we do not shortly begin to relocate some of our present day highways, built years ago principally for horse-drawn traffic, and to remove some of the safety devices that we are now using and make the highways really safe without their use, we are going to find ourselves in the same position that the cities and towns are finding themselves in regard to the parking situation. Every effort should be used within, of course, the theory of economy, to eliminate every possible warning or safety device.

Highway engineers must carefully study their locations and relocations with an idea of creating, as traffic increases, as few dangerous conditions as possible, so as to decrease the use of such devices, for as we increase and improve the surfaces, we can expect a greater rate of speed which will be productive of more accidents unless we do.

The indifference of the general motoring public to safety seems to be the reason why many of these devices are in use. I see no reason at all for the use of the white line on curves or at the top of a hill. This white line, no doubt, increases our maintenance cost on some highways more than it benefits traffic, because it keeps the traffic in a rut. If there is a motor vehicle operator at the present time who is not educated up to the fact that he should drive on the right-hand side of the road at a curve or on a hill, and should not pass vehicles where the sight line is obstructed, then it seems to us that his education has been sadly neglected, and the most effectual safety device for him is ten days in jail.

Many safety devices are used not with the idea of prevention of accidents, but so that the responsibility for the accidents may be placed after the accident. The white line painted on pavements is much over-worked for this purpose.

To me, signs used for the purpose of giving directions as to the allowable speeds are faulty for they encourage a speed which may be unwarranted by the traffic conditions, by the limitations of an operator, by the limitations of the vehicle and the highway. They seem to set up a standard for operation which all drivers cannot meet.

The purpose of any device should be to move traffic and not retard it, and it has always seemed to me a short-sighted policy to place a device at an inconvenient point in the highway so traffic will necessarily have to slow down to make the movement, creating bottle necks, as if you have studied traffic, you know that traffic will do the thing which is most convenient whether or not it is safe; and the inconvenient sign is only effective when an officer is watching it.

Devices containing advertisements are little more than useless. Personally, I have always felt that the so-called light houses, flashing beacons, silent policemen and other devices of the same type within the traveled path were a detriment to safe traffic direction and cause more traffic accidents than they prevent. I know all that is claimed for them, but I have always failed to see the wisdom of spending thousands of dollars for the elimination of dangerous locations and then placing an obstruction within the traveled path. It has been my experience that with

care and study some other method might be devised which would eliminate the necessity for them.

It is realized that much of this paper has been my own personal opinion, but that opinion has only been formed after careful study and experiment both with light and congested traffic, on state highways only.

Any part of this paper is not intended to apply to the city problem, as to my mind those problems are entirely different.

I also realize that the subjects of this paper may be debatable, depending upon the section of country you use as your laboratory, but the principle to be used in the placement of any safety device cannot, I believe, be questioned, and that principle is that the device must not restrict traffic farther, but grant it additional safety, speed and convenience. The use of the highway police or highway safety devices should never violate that principle.

VARYING QUANTITY OF CEMENT IN PLAIN AND REINFORCED CONCRETE

(Editor's Note: The following address was delivered before the Institution of Civil Engineers on Nov. 11, 1925, in England, by Sir E. Owen Williams.)

It is a familiar experience to all of us to discover in the middle of a design or when construction is far advanced that conditions which fundamentally affect the work have changed, disappeared, or even proved never to have existed. Our mental laziness, perhaps sub-conscious, tempts us to leave the work, even if we modify it, still bearing the impression of these conditions. If we fall to this temptation the result will be unatisfying. A satisfying work is one which satisfies only real conditions. It makes the difference between the masterpiece and mediocrity. Thus the result of improperly treated changed conditions is, in practical work, tantamount to failure.

The first use of concrete was in mass, and, as that word signifies, weight was intrinsically valuable. The thickness of a retaining wall could be no less, whatever the quality of the concrete; hence engineers came to understand that the necessary amount of cement in mass concrete was only such as would prevent the concrete returning to original ballast. In this connection experimental work was devoted to determining mixes of ballast and sand demanding the least amount of cement.

Reinforced concrete arrives, and no longer is the weight of concrete of any value; indeed, it becomes a burden to be reduced. New values come into prominence. Compressive strength, adhesion to steel, water-tightness become of primary importance. Increased values in any of these enable a reduction of sizes, and are, therefore, much to be desired. This is a different view-point of concrete. In one case it is a question of determining the least amount of cement for a given and fixed mass of concrete; the other is a case of getting the maximum compressive strength, adhesion to steel, and maximum water-tightness, with the least weight of concrete.

Influence of Percentage of Cement

Some years ago I made a series of experiments to determine the influence of the percentage of cement on these qualities of concrete, assuming equal care in grading of aggregates for all mixtures. From the results of my experiments, which were considerable, I came to the conclusion that all properties of concrete varied directly with the percentage of cement in the finished concrete. For example, a 4:2:1 concrete has approximately 510 lbs. of cement per yd. cube of concrete, whereas in a 2:1:1 concrete the cement weight is 860 lb. per yd. cube, and if it were reasonable to take 510 lb. per sq. inch compression on a 4:2:1 concrete, experiment showed that it would be equally reasonable to take 860 lb. compression on a 2:1:1 concrete.

The significance of this is that in a column of any size, within limits, a ton of cement will give the same bearing capacity whatever the size of column. Thus, there is no ineconomy in rich mixtures—in fact, there is the reverse. Using the higher percentage of cement paradoxically results in no increase in the quantity of cement, but it reduces the quantities of aggregates, moulds and weight. Adhesion to the steel is increased—a most desirable result, as it is this adhesion that ultimately determines the strength of the structure. Also, whereas a 4:2:1 mixture is seldom watertight, a 2:1:1 concrete is seldom *not* water-tight, resulting in increased permanence of construction, because of less risk of steel corrosion.

Indeed, the cement in reinforced con-

crete may be likened to the reinforcement. The reinforcement is calculated by itself, and results in so many tons. The cement could also be calculated in so many tons, and then you would only have to make up your mind what bulkage you have to add in the way of ballast and sand to make the size of members practicable.

Two View-Points

In brief, mass concrete must contain a predetermined and fixed weight of aggregates with as little as possible of cement, whereas reinforced concrete must contain a predetermined and fixed weight of cement with as little as possible of aggregates. Two entirely different viewpoints of concrete.

I am afraid that in the majority of structures built in reinforced concrete, the concrete has very hesitatingly and timidly been made a little better than mass concrete, being fallaciously regarded from the same standpoint, i. e., from the standpoint of saving cement, whereas in reinforced concrete it is a case of saving ballast and sand, the cement being a fixed tonnage.

It will be asked where should this increased percentage of cement end? Why not use cement only? The answer is that the practicable sizes of members demand a greater volume than would be economically supplied by the calculated weight of cement, and to produce these sizes ballast and sand are necessary, although it is quite possible that in certain structures, where loads are considerable, the amount of ballast and sand would be very small.

I have prepared the following table showing relative costs of slabs to carry the same load on the same span and columns carrying the same load:

Slabs	Relative cost Per cent.
6 in. slab in 4:2:1	100
5¼ in. slab in 3:1½:1	97
4 2-3 in. slab 2:1:1	97

All carrying same super load on same span.

Columns	Relative cost Per Cent
12 in. columns 4:2:1	100
10-72 in. columns 3:1½:1	88
9-5 in. columns 2:1:1	76

(In the second table each of the columns carries same load, neglecting reduction of weight by use of less concrete in floors and slabs, and the table is based upon reasonable allowable stresses. Both tables show the distinct advantage of the better concrete.)

I have found that in actual work the practicable sizes of beams and slabs demand a concrete somewhere between 3: 1½:1 and 2:1:1 mixtures. In practical manipulation there is no comparison between the richer mixes and the poorer. For example, in the 4:2:1 mixture 10 per cent too much water removes 20 per cent of its strength, whereas in the richer mixture of 2:1:1 10 per cent too much water only removes 10 per cent of strength. Further, in the richer mixture, because of the increased percentage of cement acting as a lubricant, there is not the same temptation to use an excess of water. The result of this, as practical experience has shown, is far greater uniformity of concrete in the case of the richer mixtures.

I find 4:2:1 mixture almost universally used, and I can only think that this is due to an inappreciation of the changed conditions from mass concrete to reinforced concrete, *i. e.*, a fallacy has been born and is being perpetuated.

COURT DECISIONS AFFECTING CHLORINATION

U. S. District Judge D. J. Campbell of the Eastern District of New York, handed down his decision on November 10th in the suit of the Electric Bleaching Gas Company and Wallace and Tiernan Company against the Paradon Engineering Company for infringement of the Ornstein Patent U. S. No. 1,142,361 which covers the Solution Feed Process of Chlorination of water and sewage. Judge Campbell found that the Patent was valid; that the apparatus of the defendant infringed the Patent and that the Patent was infringed knowingly, two of the officers of the defendants, being former employees of the Wallace and Tiernan Company. The Electro Bleaching Gas Company is the owner of the patent and that company prosecuted the suit, making the sole licensee Wallace and Tiernan Company a plaintiff with it. The court in its decision reviews all of the citations of the prior art set up by the defendant and finds that none of them anticipated the Ornstein solution process. The court orders the unusual decree including an injunction and a reference to determine the profits of the defendant and damages of the plaintiffs.